PROCEEDINGS

fifth annual meeting
of the

North Central
Weed Control Conference

December 8, 9, 10, 1948

Springfield, Illinois

1949 MEETING

Sioux Falls, South Dakota

December 6, 7 and 8

Headquarters - Cataract Hotel

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PROCEEDINGS

OF THE

FIFTH ANNUAL MEETING

OF THE

NORTH CENTRAL WEED CONTROL CONFERENCE

SPRINGFIELD, ILLINOIS

DECEMBER 8-9-10, 1948

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PREFACE

The Proceedings of the Fifth Annual Meeting of the North Central Weed Control Conference, Springfield, Illinois, December 8, 9, and 10, 1948, are herewith presented. They consist of the papers presented and the official reports of committees and forums. All questions from the floor, introductions and other discussions are omitted. In order that the report of the Research Committee might be available at this meeting, it was bound separately but it is an official part of these Proceedings.

The members of the Program Committee wish to express their appreciation to President C. J. Willard for his helpful assistance in the formation of the program plan and his attention to every detail involved in the reading, editing, and arranging of the manuscripts reproduced in this volume. For his untiring work and sympathetic interest, we are indeed grateful.

The Committee

Charles H. Keltner, Chairman
W. W. Worzella
L. M. Stahler
E. P. Sylwester
W. L. Klatt
I. P. Buchholtz
Keith C. Barrons

TABLE OF CONTENTS

Wednesday, December 8, 1948

Centennial Building Auditorium

Page No.

Address of Welcome: Hon. Harry A. Eielson, Mayor of Springfield - - 9
Coordinated Research In 1948: L. M. Stahler - - - - - - - - - - - - - 9
Pre-emergence Treatment of Corn for Weed Control: R. F. Fuelleman - 11
Pre-emergence Treatments with 2,4-D and Other Herbicides to Control Weeds in Field Crops Other than Corn: K. P. Buchholtz- - - - - - 15

Wednesday Afternoon, December 8

Centennial Auditorium

Section I - Field Crops Chairman: F. J. Greaney

The Effect of 2,4-D as a Selective Herbicide in Growing Corn and Sorghums: Oliver C. Lee- 18
Some of the Effects of 2,4-D on Spring Wheat, Oats and Barley: Lyle A. Derscheid - 21
The Response of Flax to 2,4-D: R. S. Dunham - - - - - - - - - - - - - 26
Effect of 2,4-D as a Selective Herbicide on Fall Planted Wheat, Oats and Barley: W. C. Elder- 28
The Response of Legumes Seeded as Under Crops to 2,4-D: John H. Miller- 30
Effect of 2,4-D as a Selective Herbicide in Perennial Grasses: Glenn Viehmeyer - 32

Wednesday Afternoon, December 8

Abraham Lincoln Hotel Ballroom

Section II - Horticultural Crops Chairman: B. H. Grigsby

Certain Phenolic Compounds for Residual Pre-emergence Weed Control in Horticultural Crops: Keith C. Barrons, Wendell R. Mullison, C. D. Fitzgerald and L. L. Coulter- - - - - - - - - - - - - - - - - - 34
Pre-emergence Treatments for Onions, Lima Beans, Beets and Asparagus: G. F. Warren- 39
Chemical Control of Weeds in Onions by Post-emergence Sprays: R. E. Nylund- 45
Potassium Cyanate as a Weed Control Chemical for Onions: N. K. Ellis - 48
Experiments on the Control of Weeds in Onions Grown on Peat Soil by the Use of Chemicals: A. L. Bakke - - - - - - - - - - - - - - - - 51

Page No.

Chemical Weed Control in Horticultural Crops: E. K. Alban- - - - - 58
2,4-D for Weed Control in Orchards, Shelter Belts, and
Ornamental Plantings: Glenn Viehmeyer - - - - - - - - - - - - - - 65
Some Aspects of Weed Control in Small Fruits (Preliminary Report):
R. F. Carlson- 68

Wednesday Afternoon, December 8

Leland Hotel Ballroom

Section III - Non-Tillable Land Chairman: L. W. Melander

Introductory Remarks: L. W. Melander - - - - - - - - - - - - - - - - 72
Eradication of Herbaceous Plants on Uncultivated Land:
Dayton R. Klingman - 238
Killing Undesirable Shrubs on Ranges of the Southern Great Plains:
E. H. McIlvain - 73
Clearing Woody Plants from Right of Ways: R. H. Beatty - - - - - - 79
Control of Undesirable Shrubs and Trees in a Reforestation Program:
Maurice W. Day - 85

Wednesday Evening, December 8

Abraham Lincoln Hotel Ballroom

Section I - Investigations on Weed Control Methods in Sugar Beets, Potatoes, Soybeans, Peas, and Similar Crops Chairman: E. A. Helgeson

Pre-emergence Weed Control in Sugar Beets: H. C. Young, W. E. Hall,
C. J. Willard, H. E. Bruner, Clyde Wilson- - - - - - - - - - - - - 93
Chemical Weed Control Investigations in Sugar Beets at Fargo,
North Dakota: E. A. Helgeson, C. R. Swanson, L. M. Stahler- - - 108
Weed Control in Sugar Beets in Michigan: B. H. Grigsby - - - - - - 111
Weed Control for Sugar Beets - Pre-emergence Weed Control Studies:
Russell T. Nelson- 113
Post-emergence Weed Control (Mechanical): E. P. Pattison - - - - - 119
Post-emergence Weed Control (Selective Spraying): E. P. Pattison - 123
Chemical Weed Control on Soybeans, other Legumes, and Miscellaneous
Crops: C. R. Swanson- 126
Weed Control in Potatoes by the use of Various Chemicals:
Glenn Viehmeyer - 128

Wednesday Evening, December 8

Leland Hotel Ballroom

Section II - Symposium on Research in the Eradication of Woody Plants: Chairman: L. W. Melander

Suggestions for Future Work on Problems Dealing with the Control of
Undesirable Herbaceous and Woody Plants: Harry M. Elwell, Chairman
of Suggestion Committee- 131

Thursday Morning, December 9

Centennial Auditorium

General Session

T. F. Yost, Chairman

Perennial and Annual Weeds
A. H. Larson and George Knowles, in charge

Page No.

A Survey of a Season of 2,4-D Spraying: Len Weigand- - - - - - - - 133
Annual Weed Control in the Hard Winter Wheat Belt:
W. M. Phillips - 135
The Use of 2,4-D in the Control of Perennial Herbaceous Weeds:
G. Knowles - 138

Educational and Action Programs
W. L. Klatt and E. P. Sylwester, in charge

What do we Need in Herbicide Laws?: Warden L. Now- - - - - - - - - 141
Minnesota's Short Course for Training Weed Workers: Sig Bjerken- - 146
Educational Activities in Nebraska: J. D. Furrer - - - - - - - - - 149
Safety Zones in a Weed Control Program: Charles J. Gilbert - - - - 153

Thursday Afternoon, December 9

Centennial Auditorium

General Session
W. W. Worzella, Chairman

Machinery and Methods of Application
W. P. MacDonald, in charge

Spraying Equipment for Herbicides and other Methods of Application:
W. P. MacDonald- 158
A Simple Technique for Spray Nozzle Testing and Some Results:
G. L. Shanks - 165

Industrial Viewpoint and New Herbicides
W. C. Dutton, in charge

The Industrial Viewpoint: W. C. Dutton - - - - - - - - - - - - - - 168
Summary on 2,4,5-T (on Vegetable and Field Crops), MCP, PCP, Oils
and Miscellaneous New Herbicides: G. F. Warren- - - - - - - - - 174
Report on Results from Use of IPC and TCA: George L. McCall- - - - 175
Review of Results from Use of 2,4,5-T on Woody Plants and Methyl
Bromide as a Pre-planting Treatment: W. C. Dutton - - - - - - - 177

Thursday Evening, December 9

Annual Banquet
Toastmaster: Arnold P. Benson

Page No.

1948 Observations: C. J. Willard - 178
Remarks Presenting L. W. Kephart: C. J. Willard- - - - - - - - - - - 180
Remarks Accepting Honorary Membership: L. W. Kephart - - - - - - - - 181

Friday, December 10

Centennial Building Auditorium

Section I - Physiology and Basic Studies Chairman: George McNew

Effect of Several Herbicides on Germination of Sugar Beet Seed: Charles R. Swanson - 184
Physiological Research on Weed Control at the U. S. Plant Industry Station: John W. Mitchell and Paul J. Linder- - - - - - - - - - - 188
Surface Tension and Synergism in 2,4-D Sprays: David W. Stanniforth and W. E. Loomis (This paper will be published elsewhere)
The Growth Regulant, Herbicidal, and Physical Properties of Chemicals Related to 2,4-D: George L. McNew and Otto L. Hoffman (This paper will be published elsewhere)
Some Effects of Herbicidal Oils on the Physiology of Plants: Wm. Harold Minshall and V. A. Helson - - - - - - - - - - - - - - - 193
Some Factors Influencing the Penetration and Mobility of Chemicals in the Mesquite Plant: C. E. Fisher and Dale W. Young - - - - - 197

Friday, December 10

Abraham Lincoln Hotel Ballroom

Section II - Educational Problems in Weed control Chairman: E. P. Sylwester

Introductory Remarks by Chairman- - - - - - - - - - - - - - - - - - - 203
Educational Problems of Weed Control in Missouri: Ross Fleetwood - 204
Educational Problems in Weed Control: Geo. M. Briggs - - - - - - - - 207
Report of Chemical Weed Control in North Dakota in 1948: R. B. Widdifield - 210
Educational Problems in Weed Control in North Dakota: R. B. Widdifield - 212
Educational Program in Weed Control (Indiana): Oliver C. Lee - - - 214
Weed Control Activities in Iowa in 1948: E. P. Sylwester - - - - - 215

Friday Morning, December 10

Leland Hotel Ballroom

Section III - Regulatory Problems In Weed Control Chairman: W. L. Klatt

Page No.

Reports of Committees
- Report of the Committee on Uniform Weed and Seed Laws: Charles J. Gilbert, Chairman, presented by R. C. Colburn - - - - 217
- Report of the Committee on Movement of Noxious Weed Seed Infested Materials: Sig Bjerken, Chairman - - - - - - - - - - - 218
- Report of the Committee on the Movement of Transient Custom Combines: Loys F. Smith, Chairman - - - - - - - - - - - - - - - - 219
- Report of Committee on Herbicide Laws: Warden L. Noe, Chairman, presented by E. H. Aicher- 220

Friday Afternoon, December 10

Centennial Building Auditorium

General Session
C. J. Willard, Chairman

Report of the Committee on Resolutions - - - - - - - - - - - - - - - - - 225
Recommendations of the Research Committee of The North Central Weed Control Conference- 226
Constitution of North Central Weed Control Conference- - - - - - - - - 236
Registrants and Participants in the Program 1948 Conference, NCWCC - - 243

FIFTH ANNUAL MEETING

NORTH CENTRAL WEED CONTROL CONFERENCE

Wednesday Morning, December 8

Centennial Building Auditorium
C. J. Willard, Chairman

ADDRESS OF WELCOME
Honorable Harry A. Eielson, Mayor of Springfield

CORRDINATED RESEARCH IN 1948

* L. M. Stahler

It is my pleasure to have this opportunity of presenting to you the activities and accomplishments of your Research Committee. To each and every member of this committee I want to express my thanks for their cooperation in 1948 and my compliments for a job well done. Having had only a very small part in their activities--our office merely acting as clearing house for these many activities, I can, without ego, state here that I know of no comparable group in any field of research that has accomplished so much on a purely cooperative basis.

Following our last committee meeting at Topeka, Kansas, last December, the plans of Uniform Projects used in previous years were overhauled and revised to fit the needs of this rapidly changing field of research. Project or investigation leaders were chosen and assigned full responsibility for the development and coordination of the research in their respective fields. In addition each project leader assumed full responsibility for summarizing and editing the abstracts and data of the cooperators in his specific field. The thorough and intensive manner in which these project leaders carried out their responsibilities and assignments is indicated by their respective reports of Projects in your Research Report. Any compliment that I could pay these men here for their contribution to our research program and to the Conference would be less than they deserve. Revised plans of research, "Coordinated Plans of Weed Control Research for the North Central Region" were mimeographed and distributed to all contributors to the 1947 research report, and on request to a number of workers outside of the Conference area. Approximately 180 copies were distributed. Copies went to all Canadian provinces, 43 states and several foreign countries. We had many requests for copies late in the season that we were unable to fill.

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* Chairman of Research Committee of the NCWCC in 1948 and Agronomist, BPIS&AE, USDA, Agronomy Division, State College, Brookings, South Dakota.

In addition to the nine Projects outlined in the original edition, a special investigation outline covering the use of herbicides in control of weeds in sugar beets was distributed as an appendix to PROJECT V. A uniform plan of investigations for determination of varietal responses of fall planted cereal grains to herbicides was prepared in the late summer as an addition to PROJECT III and sent only to workers in the fall planted grain area.

In order to bring you the results of our research at the time of this Conference, our committee has this year undertaken the assembling and mimeographing of abstracts of individual cooperators, and regional summaries of their Research projects. This report of some 200 pages covers the investigations of approximately 140 cooperator who have submitted 340 abstracts of their investigations. For your convenience, the abstracts of specialized fields of investigations have been summarized by the project or investigation leaders in each specialized field. As a special feature this report also includes a check list of perennial herbaceous weeds and of woody plants indicating their reported reaction to the several most popular herbicides. These check lists were prepared from reports of investigators by the project leaders of the respective investigations covering these fields of research and offer you the most complete and dependable check lists of this type yet formulated. A copy of this report for 1948 was available to each of you on registration and we trust that you will study it to your advantage and pleasure. Copies of this report will be sent to all contributors not registered at the Conference as promptly as possible.

This research report is to be considered as an appendix to the proceedings of this Conference to be published later. In addition, tabular summaries of data supporting abstracts of projects, have been mimeographed and distributed to research contributors only as an appendix to the Research Report.

On suggestion of many cooperators our Committee this past season got out two mimeographed news letters, covering reported and observed progress of investigators, new developments in weed control research, personnel items and notes on weed publications. The popularity of these news letters is indicated by the fact that our original mailing list of approximately 120, jumped to around 300 with the second news letter on request from weed research workers outside the North Central area. As per agreement with contributors, news letters were sent only to institutional workers.

The Research Committee has been in session since Monday noon, and has devoted much time to the formulation of a Policy Report covering recommendations for use of herbicides in 1949. This report is being mimeographed and will be distributed on Friday at 1:30 P.M.

During the three day program you will be given comprehensive reports of many of our Projects by research men who have established a wide reputation in their specific fields as Project leaders in our Research Committee. All talks presented as contributions to the three day formal program will be included in toto, in the Proceedings of the NCWCC.

In closing, I take this opportunity, in behalf of the Research Committee, to express our appreciation and thanks to the individuals and institutions who have so generously assisted us in carrying out our Coordinated Research Projects. The Cereal Division of the Bureau Plant Industry of U.S.D.A. has been most considerate in furthering the interests of our Committee with generous quantities of mimeographing supplies and use of stenographic help. The Agricultural Experiment Stations of the States and Provinces have likewise been wholly cooperative in furnishing facilities to our members and to the group as a whole. We are likewise grateful to the many commercial organizations who have generously supplied us with herbicides and technical information and who have in no small part been active in our researches and investigations.

The Research Committee has asked me to express our appreciation and thanks to Mr. Charles Keltner, as chairman and to his entire program committee for the facilities that they have made available to our research group for the pre-conference meeting that has been in session the past two days.

PRE-EMERGENCE TREATMENT OF CORN FOR WEED CONTROL

R. F. Fuelleman, Associate Professor Crop Production
Department of Agronomy, University of Illinois

Pre-emergence treatment of corn with chemicals means treatment of the soil any time after the crop is planted and before it emerges. To those of us who are working directly with applications of 2,4-D or other chemicals, the term pre-emergence is taken for granted but it is frequently confusing to the layman.

It is either fortunate or unfortunate, depending upon one's perspective, that each succeeding crop-growing season differs in some or many respects from the preceding one. If 1948 were the same as 1947, we would have assumed that pre-emergence treatments as used in 1947 were the answers. Most people are skeptical of a single season's results but when two successive seasons give the same answer, it is more acceptable.

Interest in the use of chemicals for pre-emergence spraying of the soil to control weeds is certainly justified but no one of us is prepared to accept it as an answer to all weed problems. Doctor Ahlgren and Mr. Wolfe of New Jersey state that some 1000 acres of corn were treated with chemicals as a pre-emergence application. I suppose that in the North central states many thousands of acres were treated by hybrid corn growers, but we do not have access to these data.

Factors Involved In Pre-emergence Treatment of Corn

If someone had asked last year what factor was the most important in pre-emergence treatment of corn, the answer probably would have been the soil. In the light of the 1948 results, some modification is necessary for soil or soil types are subject to the impacts of temperature and moisture which in turn produces an environment and results differing from the preceding season. Fertile loam soils give better results with pre-emergence spraying than sandy or clay soil of lower fertility, again largely as a result of the interaction of temperatures and moisture, both atmospheric and soil. Sandy soils are usually droughty and with relatively high temperatures dry out rapidly. Clay soils are cold soils and germination of warm temperature weeds is considerably delayed during cold, wet springs, as 1947. Consequently, in late plantings, with pre-emergence treatments, fair control of both broad-leaved annual and grass weeds was obtained because loamy soils are warmer and weed seed germinated more rapidly. It is easy to become enmeshed in a host of conflicting problems and questions here, but in general the above statements hold true.

Time of planting is of importance because the optimum time of germination for weeds differs just as it does for crops. As an illustration, annual smartweed in this latitude germinates in late March or April, crabgrass in June; and pre-emergence treatment of corn in mid-May will destroy the smartweed seedlings and late germinating smartweed, but the effect of the chemical may be weakened or entirely dissipated by the time the crabgrass emerges. The end result of all this is few annual broad-leaved weeds and very large populations of grass weeds. It has been a hope, perhaps a forlorn hope, that the use of 2,4-D and other weed chemicals might preclude the necessity of cultivation of corn. Whether this is desirable or not is open to question; however, it would seem from the results obtained this year in the various states that cultivation will be necessary. It may be possible that after a period of years of treatment with chemicals, cultivation may be eliminated on some soils by the use of pre-emergence treatments.

Perennial weeds coming from rhizomes and rootstocks have not been seriously affected by 2,4 D pre emergence treatments. Most seedling broad leaved weeds have either been destroyed or shown varying degrees of damage depending upon the other factors previously mentioned. One of the important findings in this year's work was that with a reduction of populations of broad-leaved weeds, i.e., cocklebur, pigweed, smartweed, etc., an increase in narrow-leaved or grass weeds was noted where treatment was not supplemented by cultivation following emergence. These infestations of grass weeds were heavy and proceeded to occupy the ground with the result that corn had to compete with grass weeds for light, water and nutrients, particularly nitrogen, at that stage in its growth cycle when water and nitrogen were most necessary for growth and reproduction. It illustrated very aptly the ecological relationship between plants. As in other things, the larger a plant is and the faster it grows the better its chances for successful competition.

The 1943 Results of Pre-emergence Treatment of Corn

Of the several 2,4-D materials used in pre-emergence treatment of corn, no one can be said to be superior to the other when the rates of application were similar. Some preference was noted for specific formulations, chiefly because solubility, miscibility, or factors other than its killing properties. Reports of the results came from the state and provincial experiment stations of Indiana, Ohio, Wisconsin, Ontario, Quebec, Kansas, South Dakota, Oklahoma, and Illinois. The concensus of opinion in these reports indicated less concern about the formulation than about its physical properties. Our greatest concern in Illinois, one that caused considerable trouble at the time of application, was the solubility of the sodium salt as compared with the ester and amine. We found that it was necessary to use slightly more than twice as much water to make the salt sufficiently soluble to pass through the same nozzle used for the ester. This is a mechanical difficulty and can be overcome. No cooperator as far as I could ascertain used 2,4-D or other chemicals in the dust form this year. In 1947 we made some experimental applications of an ester dust, and were rather impressed; however, the control of drift was an obstacle to its continued use.

In pre-emergence work, it is possible to use larger per acre applications of 2,4-D without unduly endangering the crop. From all stations reporting on pre-emergence work with corn, four pounds of acid seems to be the upper and 1/3 of a pound the lower limit used in the 1943 program. Although considerable variation is evident in yields as between stations and also between quantities used, yield differences are largely attributable to the weed populations and not to the chemical used. However, in most cases the higher rates of application of 2,4-D were responsible for lower weed populations and higher corn yields. On fields where cultivation was not used in conjunction with spraying this holds true. On fields and plots in a rotation and where cultivated crops are a regular part of that rotation, weeds and weed populations are less vigorous and smaller, consequently yields do not differ greatly. Such was the case at Urbana, Illinois. Higher rates gave better yields and these were reported by Zahnley and McCall of Kansas, Buchholtz of Wisconsin, Lee of Indiana, McKibben, Webb, and Fuelleman of the Illinois Dixon Springs station, Elder of Oklahoma and Derscheid and Kratochvil of South Dakota. The results obtained by Aldrich, Shaw, and Willard of Ohio, follow a less pronounced trend, however, yields of treated plots averaged 15 bushels more per acre than on uncultivated, untreated checks.

One of the important considerations in ascertaining quantities of material to be employed is cost. In light of the cost factor, the minimum amount of 2,4-D that will give the highest consistent yields and best weed control with a reasonable margin of safety will be the one to use. As stated previously, the reports from cooperators indicated 1/3 to 4 pounds of 2,4-D per acre. These were minimum and maximum quantities. The average quantity, most consistent with weed control and corn yields was 1 to 2 pounds per acre. Cost of this amount of material is not excessive.

On the basis of the few reports from cooperators that indicated the type of and quantity of carrier or diluent, it is not possible to summarize the trend in this respect. Elder of Oklahoma and Slife of Illinois used approximately 40 gallons of water as diluents. Bruner and Hall of the Monsanto Company used 100 gallons of water as a diluent with Santobrite, Sulfasen, and dinitro compounds. McKibben at the Dixon Springs station used 5 and 11 gallons

of water, the latter the least amount that could be used to bring the sodium salt into solution. Is the quantity of carrier a factor in pre-emergence results? In our opinion, it is a factor only as it may prevent or enhance the uniform distribution of the spray material.

Analyses of the research abstracts from the various state and provincial experiment stations show:

1. None of the rates of application of 2,4-D caused injury to the corn. Wolf and Ahlgren, of the New Jersey station have noted some injury, chiefly loss of polarity, stunting, and reduction of 5-10 percent in stands when more than two pounds of 2,4-D acid were used. Derscheid and Kratochvil of South Dakota apparently observed no injury from one, two, or four pounds of 2,4-D, but did have a significant decrease in yield from four pounds of dinitro applied at seeding time and two and four pounds applied three days after planting and at emergence. Bruner and Hall used Santobrite, Sinox W, and Sulfasen at 20, 8, and 5 pounds respectively per acre. Sinox W caused some injury and reductions in the stands of corn.

2. Yield reductions of corn were noted from all stations where 2,4-D was used on plots and fields with no subsequent cultivation as compared to normal cultivation procedures. The exception to this statement was one series of plots at Urbana where cultivated plots yielded no better than uncultivated and/or treated plots. This field has been rather free from weeds for some years. Referring again to the first statement relative to yield reductions, it appears that grass weeds occupy space ordinarily occupied by broad-leaved species where no cultivation is used. On this, Doctor Willard and his associates of Ohio, Doctor Buchholz of Wisconsin, Doctor Zahnley of Kansas, Doctors Derscheid and Kratochvil of South Dakota, Doctor Elder of Oklahoma, Messers. Bruner and Hall of the Monsanto Co., Doctors Bordeleaux and Corteux of the Quebec station, Professor Lee of Indiana, and the Illinois stations are in agreement. Obviously, pre-emergence treatments are most effective in conjunction with cultivation and it is our conviction that it can be useful in this respect in ultimately reducing stands of broad-leaved weeds on consistently treated farm lands to a minimum.

3. Time of application i.e. planting time, three and six days after planting and at emergence were used by some cooperators. Willard compared five days after planting with spraying at planting time with a slight increase in yield for the delayed spraying. Zahnley and McCall made all applications four days after planting. Derchied and Kratochvil compared planting time, three days after planting and emergence spraying and the three days delayed spraying gave the best corn yields. Professor Lee used three days after planting sprays but did not comment on the comparisons.

McKibben, Webb, and Fuelleman at the Dixon Springs station compared sprays of butyl ester and the sodium salt of 2,4-D at planting time, three days and six days after planting. Yields of corn were highest and weed control better with the six days after planting applications with the heavier rates of 2,4-D i.e., four to eight pints of butyl ester and two to four pounds of sodium salt. This was followed rather closely by the three days after planting spray applications. At Urbana corn had emerged at six days after planting, therefore, the comparisons were for planting time and three days delayed. No significant difference in yields was obtained, although the delayed spray plots had fewer grass weeds at the higher rates. Wolf and Ahlgren of New Jersey, state that five days after planting gave the best results depending upon emergence of the corn. From the reports received and our own experiences it is safe to state that delayed pre-emergence spraying is definitely more effective than spraying at planting time. The danger in delayed spraying lies in the chance of heavy rains in the interim sealing or crusting the soil surface. Conversely, on a loose seedbed, spraying at planting time followed by rains can dissipate the spray materials so that their best effect will not be obtained.

In conclusion, I would like to mention work by Zalik and Olson of the University of Manitoba at Winnepeg. In a study of the residual effect of 2,4-D on corn, using the butyl ester and sodium salt at one pound of acid per acre, four days after spraying, a dense stand of pigweed emerged on both sprayed and check plots. All were thoroughly cultivated. Following this the check plots were again infested with pigweed but the treated plots remained relatively free of weeds. Hermandez at Wisconsin sprayed golden cross bantam sweet corn, pre-emergence, and followed up with post-emergence 24 and 35 days after planting. The pre-emergence treatments gave much better control of both broad-leaved and grass weeds. No significant reduction in corn yields occurred from any of the treatments. Also somewhat different from other pre-emergence work was that of Bordeleaux and Corteux of Quebec, Canada. They used the salt, ester, and amine of 2,4-D in pre-emergence treatment of silage corn, one pound of acid per acre, three days after planting. Although the yields of corn were about 20 percent higher than in cultivated checks, cultivation yielded three times as much. In another series higher rates of application (4#) 10 days after planting gave yields approximately 75 percent of cultivated checks and good control of annual weeds.

In our opinion, pre-emergence treatment for weed control is definitely advantageous if cultivation also is used. Pre-emergence spraying alone without cultivation cannot be depended upon to give the control necessary of grass weeds and perennials in corn. Certainly we do not have all the answers to all of the conditions of soil, climate, and crops, but the data received does show the general trend of this method of weed control.

PRE-EMERGENCE TREATMENTS WITH 2,4-D AND OTHER HERBICIDES TO CONTROL WEEDS IN FIELD CROPS OTHER THAN CORN

K. P. Buchholtz

Thirty-three abstracts dealing with the pre-emergence control of weeds in field crops other than corn were received. Reports were submitted from areas as widely separated as Ohio, Oklahoma, and Canada. Data on a number of crops were submitted but the majority were on the spring grains, wheat, oats and barley.

Results obtained were erratic. In a few instances good weed control was obtained without crop injury but more often partial weed control and partial crop injury were noted. In many instances no weed control or crop injury followed application of the herbicides. It is certain that a number of factors influenced the weed kill and crop injury observed but their relative importance cannot be determined exactly since no more than one or two factors even occurred in a single trial. Weed control varied from good to none and crop response varied from no effects as measured by stand or yield to severe reduction in stand and moderate reductions in yield. The reduction in stand was the most frequent crop injury noted but stunting of the emerged plants, yellowing, abnormal heads and roots and reduction in tillering also occurred.

Probably the most important single factor affecting the success of pre-emergence weed control was soil moisture conditions at time of application and during the week or two following. In no case was effective weed control obtained when applications were made to dry soils and rainfall did not occur for several weeks. Likewise no instance of crop injury was ever reported under such conditions. Best results were obtained when applications were applied to moderately damp soils and were followed by moderate amounts of precipitation. Weed control was usually fair to good under such conditions and crop injury was usually moderate if present at all. Excessive amounts of rain following application often resulted in excessive amounts of crop injury. The extent of the soil moisture at time of application and the precipitation following the chemical application were not given exactly in many abstracts. If these investigations are to be continued it would be desirable to have detailed records on these factors available since they play a predominant role in the successful use of this weed control technique.

The different crops studied showed some difference in susceptibility to chemical application. Sunflowers, sugar beets, sweet clover, alfalfa and bromegrass appeared to be especially sensitive to applications of 2,4-D. This may have been due to their shallow planting rather than inherent susceptibility. As a group the grains were fairly tolerant to the effects of 2,4-D. Barley appeared to be most tolerant, with oats the least tolerant, wheat both spring and winter and spring rye were intermediate. Peas, soybeans, flax and sorghum appear to be intermediate in their degree of tolerance. Exact comparisons cannot be made since all crops were never included in a single experiment.

Most of the reports received described the use of 2,4 D as the pre-emergence herbicide. A series of trials including the ammonium salt of dinitro-o-sec-butylphenol were reported from North Dakota, South Dakota, and Minnesota. This material was applied at rates up to 2 gallons of a 13 per cent preparation per acre to various small grains and flax. In no case was any crop injury reported following such treatments but weed control was never effective. Dinitro-o-sec-amylphenol at rates up to 4 pounds per acre in several instances likewise was ineffective in weed control and had no noticeable effect on crop growth. The use of IPC at rates of from 2 to 8 pounds per acre reduced flax stands as much as 30 percent but did not affect ultimate yields significantly. TCA at rates of from 6 to 24 pounds per acre caused reductions in stand of up to 40 percent. This material also caused significant reduction in flax seed yield when applications of as little as 6 pounds per acre were made at seeding time. Good control of Setaria Species was obtained with TCA in this experiment.

The most complete comparison of 2,4-D preparations was carried out at Saskatoon, Sask. The tolerance of small grains and flax to the various preparations of 2,4-D was determined using irrigation to maintain soil moisture at high levels. The experiment showed that the micronized form of 2,4-D in the acid form was consistently least toxic to the various crops of any material tested. It was as effective as the other forms in weed kill. 2,4-D which was used only in the ester form usually caused the most severe crop stand reductions. The sodium salt, amine and ester preparations of 2,4-D gave approximately equal reduction in crop stand.

Soil type undoubtedly has an effect on the crop and weed response obtained following treatment. None of the experiments gives much information on this point but in several instances crops planted in the more sandy soils were injured by moderate amounts of 2,4-D. It is probable that leaching of 2,4-D by rainfall is somewhat more rapid on the lighter soils and is responsible for the relatively severe injury observed in some cases on these soils.

The time of chemical application after planting the crop influenced the amount of crop injury observed in a number of instances. Delaying application until the crop is nearly ready to emerge usually resulted in less or at least no more injury than where applications were made immediately after planting. It should be pointed out that delayed applications are sometimes difficult to make because of unfavorable weather and applications made after the crop has started to emerge almost invariabl result in various abnormalities in the growth of the crop.

Varietal effects were noted in only a few instances. In a study in Ohio, Hawkeye soybeans showed considerably less injury than four other varieties. A similar trial in Minnesota, using most of the same varieties, showed no superiority for the Hawkeye variety. In Nebraska the Nemaha and Clinton varieties of oats responded in a similar manner. There may be varietal differences in response to 2,4-D in many of the field crops but most of the trials included only one variety and exact comparisons cannot be made.

Depth of planting also has an influence on the response of the crop plant. The more shallow plantings tend to be injured to the greatest extent. Depth of planting is limited by the ability of the crop seedling to make a satisfactory emergence but within these limits it appears that the deeper plantings provide some degree of safety from crop injury over the more shallow plantings.

Rates of 2,4-D application for most successful use as pre-emergence applications in these crops would appear to be between 1 and 2 pounds per acre. Under very favorable conditions good weed control was obtained with 1 pound applications. To insure weed control under somewhat less favorable conditions applications of from 1½ to 2 pounds would probably be most practical. Heavier applications seldom resulted in significantly greater weed kill and the crop hazards were distinctly greater with these applications.

Only incidental studies concerning the resistance of various species of weeds to pre-emergence applications were reported. The annual grasses were of course noted as being quite tolerant of 2,4-D but capable of being killed under favorable conditions. The various species of mustards, appear to be quite susceptible to 2,4-D. Red root pigweed and Russian thistle are reported as being somewhat tolerant while wild buckwheat is even more resistant.

In summary it appears that pre-emergence control of weeds in field crops was not generally satisfactory throughout the region in 1948 primarily because of the poor weed control obtained and secondarily because of the injury to crops that occurred. It is recognized that some instances of good weed control without crop injury were observed which indicates that the pre-emergence control of weeds in field crops may develop into a practical technique. Unless methods of application and crop culture can be developed that will offset the weather hazards successfully it is unlikely that pre-emergence weed control techniques can be used widely on the field crops reported upon in this area.

Wednesday Afternoon, December 8

CENTENNIAL AUDITORIUM

SECTION I - FIELD CROPS

CHAIRMAN, F. J. GREANEY

THE EFFECT OF 2,4-D AS A SELECTIVE HERBICIDE IN GROWING CORN AND SORGHUMS.

Oliver C. Lee, Purdue University

Last year at this time I had the pleasure of addressing this group on practically this same subject. I can recall, and I am sure at least some of you remember, that we agreed that much more experimental work was needed before numerous questions regarding the use of 2,4-D in corn could be answered.

What were some of the points we discussed last year? It might be worthwhile to review them briefly just to compare our thinking of last year with this year, after one more year of extensive research on the problem. Most of us saw the need for more adequate weed control in corn. Wet weather during the spring and early summer throughout the corn belt made cultivation for weed control practically impossible. Because of these conditions, numerous farmers had taken a chance, so to speak, spraying rather extensively. It was apparent that 2,4-D would kill weeds of the broad-leaf variety. It was also apparent that corn would withstand dosages that would destroy many weeds common to corn fields.

It was generally conceded that large corn, 12 inches in height or taller, was more tolerant to 2,4-D than smaller corn. Over-dosages should be avoided as there is great danger of seriously damaging the corn. 1/2 pound of 2,4-D per acre was suggested as the maximum dosage. When the ester formulation of 2,4-D was used, a dosage of 1/4 pound per acre was suggested. When spraying large corn, row crop type sprayers that would place the spray below the leaves of the corn plant appeared to be practical, so as to allow only a minimum amount of spray to come in contact with the corn plant. Questions of effect of 2,4-D on chemical composition of corn and on the progeny from sprayed corn were not answered.

During the early part of the year 1948, several state experiment stations published leaflets or bulletins on the subject of spraying corn. They were not submitted to encourage the practice but to meet the demand by farmers for advice and guidance. The demand for this information was so great that approximately 100,000 copies of leaflets published by Purdue University were distributed. Dosage, time to spray, method of application, weeds susceptible and resistant and type of equipment suitable, were discussed. Seed producers were cautioned against spraying of seed fields as there was a possibility that 2,4-D might affect the corn when used for seed.

During the past growing season, 1948, many of the experiment station workers conducted rather extensive research. Some of it was rather fundamental in nature but much of it directed towards answering immediate questions arising from potential users of the practice of spraying corn. Since I was given the job of summarizing the results of the various reports submitted by workers throughout the north central area, the following remarks will be based on reports received from them and experimental work done in Indiana, as well as observations made from practical application by the farmer. You know, one good way to test a practice is to put it in the hands of farmers and then observe the results. I personally inspected some three hundred sprayed fields and farms under many different conditions. Corn was sprayed in Indiana from planting time until just before harvest. Of course, the principal thing of interest now, is what can be concluded from the experimental work done and observations made during the growing season of 1948. From here on I will follow a policy of making a claim or statement, and attempt to defend the statement by citing data, either those submitted by other workers or in some cases, those from my own state. Abstracts or reports were received from Wisconsin, Ontario, Illinois, Oklahoma, Nebraska, Iowa and Indiana. The Iowa report was received too late to include in the mimeographed report.

Before discussing these data, let us review weather conditions. Speaking of the corn belt area: The weather was dry, temperature 60-70 degrees for a period of 30 days or more during May and June, immediately following the normal corn planting period. During the early part of July rains fell, temperature and humidity were high, making ideal corn growing conditions. During 1947, you will recall, weather conditions were just the opposite, with cool, wet weather during June and early July.

Some degree of injury to corn can be expected when 2,4-D is applied in sufficient quantity to be of value in the control of weeds common to most corn fields. Injury is indicated some several hours (12-48) after spraying, by symptoms of stalk brittleness and lodging. Later in the season the symptoms are stalk curvature and fasciation of brace roots. Such damage may or may not be reflected in yields, depending on the severity of damage and the ability of the corn plants to outgrow the effects.

Varieties and strains of corn vary in their tolerance to 2,4-D, as shown by the degree of injury which I have just described. Differences were supported by Elder of Oklahoma, Jugenheimer, Slife and Fuelleman of Illinois, Viehmeyer of Nebraska and Lee of Indiana. In Indiana we found most of our popular white corns to be the least tolerant. Although very interesting, I will not attempt to give the detailed results of this work, as the results might well be reserved for distribution by the various states to their growers. The fact that there

is a difference is all-important and should be taken into consideration when recommending spraying to the farmer. Elder of Oklahoma reported differences in varietal tolerance in sorghums. He noted dwarfing in one variety following spraying.

Damage to corn increased as dosage of 2,4-D was increased. It also varied with the formulation of 2,4-D used. The following figures are from an Indiana experiment. Three formulations of 2,4-D were used in rates of 1/2 to 2 pounds acid per acre. Average yields in bushels per acre obtained from various rates of treatment are: 1/4 lb.= 85, 1/2 lb.= 88, 3/4 lb.= 88, 1 lb.= 83, 1-1/2 lbs.= 80, 2 lbs.= 79, checks 92. There appears to be a definite drop in yields when 3/4 lb. per acre or more was applied.

Now let us work the problem the other way. The average yields of corn sprayed with sodium salt, amine salt and butyl ester at rates of 1/4, 1/2, 3/4, 1, 1-1/2 and 2 pounds of acid per acre are 87, 87, and 74 bushels per acre respectively, compared to 92 bushels from the checks. When 1/4 pound per acre was applied, the yields of those sprayed with sodium salt produced 89 bushels, amine salt 89 and ester 84. When 1/2 pound was applied, the yields are 94, 91 and 81 for sodium, amine and ester respectively. At the 2 pound rate, the plots sprayed with sodium salt produced 86 bushels, the amine salt 81 and the ester 71. In most instances, the ester type of 2,4-D produced a greater degree of early symptoms of injury than the sodium or amine salts. Dosages of 3/4 pound or more of the ester type produce leaf burn and rolled leaf tips. This was not noted when sodium or amine salts were used.

Time to apply sprays should be determined by the weed growth. After all, 2,4-D is applied to kill weeds; therefore, spraying should be done when weeds threaten to damage the corn. Young tender weeds are easier to kill than larger ones. Experiments conducted in both 1947 and 1948 indicate that small corn (6 inches or smaller) is more susceptible to damage than larger corn. Growing conditions appear to be a factor. This year in Indiana large corn, 12 inches or more in height, was more easily damaged than small corn. The reason was apparently, because of the difference in growing conditions. The larger corn was sprayed under ideal corn growing conditions with plenty of soil moisture and high temperatures, 90 degrees or above. It is apparent that corn is more susceptible to injury to 2,4-D when growing rapidly than when growing slowly. We might, therefore, suggest to prospective sprayers of corn that they avoid spraying when temperatures are high, or if the job is done at that time, to cut the dosage to a minimum. Kramer and Willard of Ohio reported that spraying of corn with 2,4-D just before tasseling time adversely affected seed set on two inbred lines.

Recent investigations indicate that the progeny from sprayed corn is not affected. Corn from sprayed plants grow normally when planted either in the field or greenhouse. It was high in germination, equal to non-sprayed checks, and produced normal seedlings. This is a point of interest to seed corn producers. As you will recall, seed producers were cautioned about spraying seed fields this year.

As far as injury to corn is concerned, there does not appear to be much difference as to how the spray is applied. When spraying large corn, I would prefer to use drops on the sprayer that will apply the spray below the leaves of the corn plants. By so doing, a better contact can be made with the weeds.

It is difficult, especially when using low gallonage, to penetrate through the heavy foliage of the corn. For late spraying to control vines, I certainly would suggest this method of spraying. When irregular heights of weeds are to be sprayed, and the growth is dense, it might be wise to use more than 5 gallons of solution per acre to assure coverage. Under such conditions many small weeds are protected by the larger ones and unless considerable solution is applied they will not be hit by the spray.

Conclusion: It is apparent that the use of 2,4-D alone is not the answer to weed control in corn fields. Cultivation is necessary to destroy grassy weeds. On some soil types it is necessary to obtain the desired soil tilth. Fuelleman's work in Illinois and the work in Indiana this year have shown that bushels of corn per acre were increased by cultivation. In Indiana nitrogen starvation symptoms were more common on uncultivated than on cultivated fields and plots. 2,4-D is another weapon to use for weed control in the corn field. It is especially useful on extremely weedy fields where cultivation does not do an adequate job of weed control. It is also an ace in the hole, so to speak, that can be used when weeds threaten to take over the corn field for some reason or other.

SOME OF THE EFFECTS OF 2,4-D ON SPRING WHEAT, OATS AND BARLEY

Lyle A. Derscheid, South Dakota State College

Dr. Greaney and Fellow Weed Fighters: It has been my privilege to review the work that 27 research workers have done to determine the effects of 2,4-D on spring grain. In this review, I had the opportunity to study the results of about 35 separate experiments on 15 varieties of oats, 17 varieties of barley and 13 varieties of wheat. These crops were treated at several stages of growth and at several locations.

Many investigators used a statistical analysis of their data as a tool in evaluating their results. My own thinking is that this tool is very valuable on this type of experiment. Although I have a limited knowledge of statistics, I do know that they are not adapted for use on weed control data for the simple reason that too many zero's appear in the data. If one uses percent of control, he finds that untreated plots have or should have zero percent control and these data cannot be analyzed statistically. If the investigator uses the number of surviving plants or percent of surviving plants, he is bound to have one treatment or another give 100% control and leave no living plants. This may only happen on one plot, but it still makes it difficult to use statistics. As I said before, many of the investigators in this project used this tool in evaluating their results. I would like to suggest at this time that all future experiments in this project be so designed that statistical analysis can be applied. It is not always possible to complete a statistical analysis by the time this conference convenes, but it can be completed later. If this suggestion is to be followed, it means that a statistical procedure must be selected before seeding time so that the plots may be laid out to conform to the procedure.

In this study, yield is undoubtedly the most important single factor. All of the cooperators in this project recorded this factor, so I have drawn up tables showing the results of each contributor. This table appears in the

summary of PROJECT III. - THE EFFECT OF 2,4-D ON GROWING CROPS - SPRING WHEAT, OATS & BARLEY in the Research Report, therefore, I'll not repeat it here. In this table, I have recorded the maximum amount of 2,4-D acid per acre that was applied at each stage treated without reducing yield. In cases where the co-operator did not definitely state the maximum amount that could be used in the abstract, I tried to obtain this information from his tabular data. I tried to be conservative on the amount and in some cases did not make an entry in the table when I was not certain.

I will discuss each variety separately and try to give you the findings of each investigator and at the end I'll give a short summary. In doing this, I will mention different rates of several formulations. In all cases, I refer to the pounds or ounces of 2,4-D acid per acre applied in the various formulations.

Clinton oats has been treated at several different stages and appears to be relatively tolerant at all stages. Shaw and Willard of Ohio state that 1 pound of each formulation caused visible injury to early stages of growth, but did not depress yields when applied at emergence and at eight later dates ending with the milk stage of growth. They also indicate that 4 pounds of each formulation did not depress yields after being applied to grain that was 6 to 8 inches high at tip of extended leaf. Derscheid, Stahler and Kratochvil did not obtain depressed yields in 1947 when 1 pound of each formulation was applied to this variety when 3 inches tall, 12 inches tall and fully tillered, 10% headed, and fully headed, but did obtain depressed yields in 1948 when 1 pound of ester was applied at the 3 inch and 12 inch stages. They also report the production of "onion leaf" on plants treated with the ester at the 3 inch stage. Buchholtz of Wisconsin, likewise, reports no decrease in yields from 1 pound of each of 3 esters, 2 amines and one ammonium salt of 2,4-D, an ester of 2,4-5T and MCP when Clinton was 24 inches tall and starting to shoot heads. He, however, did depress yields at this date by applying 1 pound of a sodium salt of 2,4-D and 1 gallon of a 13% dinitro-O-sec-butylphenol, which was applied in 80, 40 and 20 gallons of water per acre. Goodwin, Slife and Fuelleman of Illinois applied one treatment - 1/2 pound of sodium salt to Clinton and Clinton 11 when the grain was 8 inches tall without depressing yields. Buchholtz and Derscheid-Stahler-Kratochvil report that viability was not affected by the application of 2,4-D.

Mindo was not tested as extensively as Clinton, but Goodwin, Slife and Fuelleman did not depress yields when they applied 1/2 pound of sodium salt to this variety when 8 inches tall. Mindo was treated two years in South Dakota. Yields were depressed one year by applying 1 pound of ester to the 3 inch and 12 inch or fully tillered stages of growth, but not when a like amount of amine and sodium salts were applied. Nor were yields depressed either year by applying 1 pound of each formulation to Mindo when 20% headed or when fully headed.

Richland was tested 3 years and Vikota, Tama, Brunker, Trojan and Marion were treated two years by Derscheid, Stahler and Kratochvil. One year the 1 pound rate of ester depressed yields when applied to grain 3 inches tall and 12 inches tall or fully tillered. A like amount of amine and sodium salts did not depress yields at these stages. One pound of each formulation was also applied when the grain was 10-70% headed and when fully headed without reducing yields either year. The ester also caused the production of an "onion leaf" effect when applied to these varieties at the 3 inch stage. Viability was not affected.

Ajax was treated at five stages of growth. Freisen of Saskatchewan did not obtain a depression in yield with 1 pound of each formulation on the 3-leaf, 5-leaf and shot-blade stages of growth. Olson and Zalik of Manitoba, likewise, did not depress yields with one pound of each formulation applied when the grain was 4-5 inches tall and 5 days after heading. Ficht of Saskatchewan did not depress yields of tillering grain with his highest rates of 1/4 pound ester, 3/8 pound amine and 1/2 pound sodium. Godbout of Quebec, however, felt that yields of Ajax treated in the 3-leaf stage were reduced when over 1/2 pound of each formulation was used and Davidson of Saskatchewan depressed yields by applying as little as 2 ounces of ester or sodium and more than 2 ounces of amine to Ajax when in the 3-leaf stage.

Erban was tested by Godbout of Quebec in two experiments. In one experiment, the yields were not reduced by applying 1 pound of each formulation to the 3-leaf, 5-leaf and shot-blade stages of growth. In the other experiment, however, he found that 3/4 pound or more of each formulation would reduce yields of Erban when in the 3-leaf stage.

Exeter was treated by Davidson of Saskatchewan at the 3-leaf stage and by Olson and Zalik when 4-5 inches tall and again 3 days before heading. Davidson obtained reduced yields with 2 ounces of ester and sodium and with 4 ounces of amine. Olson and Zalik, however, did not reduce yields with 1/2 pound ester and 1 pound of each salt at the 4-5 inch stage, nor with 1 pound of each formulation just previous to heading.

Victory was treated by Carder of Alberta when the grain was 4-5 inches tall and again when 6-8 inches tall and tillering. He used 3/4 pound of ester and amine and 1 pound of sodium without reducing yields.

Leggett of Alberta found that Eagle was quite susceptible. He indicates that the maximum rate of application would be 1/2 pound ester and 3/4 pound of either salt at 3-leaf stage; 1/4 pound ester or amine and 3/4 pound sodium at 5-6 leaf and shot-blade stages.

At first glance one might suspect that Eagle, Victory, Exeter and possibly Ajax are more susceptible to 2,4-D. These varieties were all treated at early stages of growth with only two of them being treated as late as the shot-blade stages. Exeter and Ajax appeared to be more tolerant at this later stage. These fall in line with the majority of the other varieties, which also appear to be less tolerant at early stages of growth.

Seventeen varieties of barley were treated and the results indicate that this crop is slightly more susceptible than oats.

Wisconsin #38 was treated 3 years, Plains, Feebar, Odessa, Spartan, Kindred and Manchuria were treated 2 years and Tregal was treated 1 year in South Dakota by Derscheid, Stahler and Kratochvil. One pound of each formulation was applied when the grain was 3-inches tall, 12-16 inches tall and fully tillered, 20-60% headed, and when fully headed. The one pound of ester caused a reduction in yield of all varieties each year. This amount of amine and sodium also decreased the yields of Plains, Feebar and Odessa in 1948. All varieties were most tolerant when fully tillered in 1947, and most susceptible when 3-inches tall in 1948. These investigators also report the formation of deformed spikes from treating when the grain was 3-inches tall.

Glacier, Trebi and Compana were treated by Sexsmith of Alberta when the earliest variety was 90% headed. His results indicate that 4 ounces of ester or 12 ounces of amine will reduce yields of these varieties at this stage of growth.

Montcalm was tested more extensively. Sexsmith feels that 1/4 pound of ester or 3/4 pound of amine will reduce yields of this variety also when it is 90% headed. Brown of Manitoba reported that 1/2 pound of each formulation was the maximum amount that could be used when 8 inches tall. Other investigators indicate that this variety is more tolerant, however, Davidson of Saskatchewan felt that 3/4 pound of each formulation could be used when in the 3-leaf stage of growth and Olson and Zalik of Manitoba indicate that 1 pound of each formulation may be applied when the grain is 4-5 inches tall and again 5 days after heading without reducing yields. Olson and Zalik of Manitoba treated this variety every 3 days from before emergence until 18 days after heading. They indicate that Montcalm is tolerant of 3/4 pound of ester any time except when 1 inch tall, 2 inches tall, 4 days before heading, 1 day before heading and 2 days after heading.

Olli was treated by three investigators. Here again Sexsmith obtained depressed yields by applying 1/4 pound ester and 3/4 pound amine when the barley was 90% headed. Corns of Alberta was able to use 1/2 pound of an isopropyl ester on the 2-leaf stage, 3/4 pound when grain was 8 inches tall and 1/2 pound when bases of spikes had emerged without reducing yields. Leggett of Alberta, however, applied 1 pound of each formulation to 3-leaf, 5-6 leaf and shot-blade stages without reducing yields of Olli.

Titan was also treated by Sexsmith and yields were reduced when 1/4 pound of ester or 3/4 pound of amine was applied when this variety was 90% headed. The maximum rates applied by Ficht of Saskatchewan were 4 ounces of ester, 6 ounces of amine and 8 ounces of sodium. These rates, when applied to the tillering stage of growth did not depress yields. Friesen of Saskatchewan did not reduce yields of Titan when he treated it with one pound of each formulation in the 3-leaf, 5-leaf and shot-blade stage of growth.

Brown treated Vantage with 1/2 pound of each formulation when the grain was 8 inches tall, while Olson and Zalik applied 1/2 pound ester and 1 pound of each salt when the grain was 4-5 inches tall without reducing the yield. Davidson, however, was able to use as much as 3/4 pound of each formulation when the grain was in the 3-leaf stage without depressing yields in Saskatchewan. One pound of each formulation was applied 5 days after heading, however, by Olson and Zalik without causing any ill effects on the grain.

Lico and Club Mariout were treated by Bohmont of Wyoming. He indicated that yields of Lico were not reduced when 1/2 pound of each formulation was applied as spikes were emerging and that 1 pound of each formulation may be applied after this variety is fully headed. Club Mariout, however, was less tolerant as 1/2 pound of each formulation reduced yields after being applied when spikes were emerging, and 1 pound of ester and amine also reduced yields when applied to the fully headed stage.

Bohmont, Olson - Zalik, and Derscheid-Stahler-Kratochvil all indicate that barley may show a varietal difference in response to 2,4-D. The work done by Sexsmith, however, does not bear this out. It will be remembered, however, that Sexsmith treated several varieties, none of which were treated by Bohmont

or Derscheid-Stahler-Kratochvil. Barley is, in general, like oats in that it tends to be less tolerant at the early stages of growth. Barley also has a tendency to be less tolerant of the ester formulation than does oats, especially when high rates of application are used.

Thirteen varieties of wheat were treated by ten investigators or teams of investigators.

Thatcher was tested more extensively than any other variety. As growth advances, this variety becomes more tolerant. Leggett of Alberta and Foster of Saskatchewan were not able to apply over 1/2 pound of any formulation at the 3-leaf or 5-6 leaf stage of growth without reducing the yield. Davidson of Saskatchewan, however, was able to use 3/4 pound of each formulation in the 3-leaf stage while Olson and Zalik were able to use 1 pound of each formulation when the grain was 4-5 inches tall without depressing yields. Bohmont, of Wyoming also reduced yields when he applied 1 pound of each formulation while the grain was tillering. Helgeson of North Dakota treated this variety when it was fully tillered and Bohmont treated it in the boot and fully headed stage. Each reported that yields were not depressed by 1 pound of each formulation.

Helgeson of North Dakota reports that Mindum, Carleton, Mida, Rival, Pilot, and Regent were tolerant of 1 pound of each formulation at the fully tillered stage. Both Helgeson and Bohmont reduced the yield of Mida, however, by applying 1/2 pound of each formulation to the boot stage of growth. Bohmont reports that Mida is tolerant of 1 pound of each formulation at the fully headed stage, however.

Rescue, Redman, Saunders, Lemhi and Marquis were treated when in the late boot stage by Sexsmith of Alberta. He concluded that 12 ounces of ester reduced the yields, but that a like amount of amine did not. Freisen of Saskatchewan treated Rescue with 1 pound of each formulation in the 3-leaf, 5-leaf and shot-blade stages of growth without reducing yields. Ficht applied 4 ounces of ester, 6 ounces of amine and 8 ounces of sodium without reducing yields of Rescue when the grain was tillering freely. When Davidson of Saskatchewan treated Redman at the 3-leaf stage, he found that 1 pound of sodium did not reduce yields, but he was indefinite as to the effect caused by the ester and amine. Olson and Zalik treated Redman with 1 pound of each formulation when 4-5 inches tall and again 10 days after heading. They report that 1/2 pound of ester or 1 pound of either salt did not reduce yields at either stage.

Stewart was treated when 4-5 inches tall and 2 days before heading by Olson and Zalik. They indicate that this variety is tolerant of 1 pound of either salt at both stages. This variety is tolerant of 1 pound of ester when 4-5 inches tall, but yields were depressed when this treatment was applied just prior to heading. The maximum rates of 4 ounces of ester, 6 ounces of amine and 8 ounces of sodium salt did not depress the yield of this variety when Ficht made the application as the grain was tillering freely.

Wheat is in general less tolerant than oats, but more tolerant than barley. Wheat appears to be more susceptible at early stages of growth and when in the boot stage as is barley. Wheat is more tolerant of the ester than barley and does not show as much varietal difference in response to 2,4-D.

These data indicate that all three crops are less tolerant at early 3-leaf and 5-leaf stages of growth than after they have become fully tillered. The most susceptible period, however, is when heads are emerging from the boot. Oats appears to be the most tolerant of the three crops, since 13 varieties have been reported to be tolerant of 3/4 to 1 pound of the amine and sodium salts at the 3-leaf or 5-leaf stages of growth and 11 varieties were tolerant of 1 pound of each formulation while heading. Wheat is intermediate in its tolerance to 2,4-D. Four varieties were tolerant of 1/4 to 1 pound of ester; and 1/2 to 1 pound of each salt when the crop was in the 3-leaf and 5-leaf stages of growth, but seven varieties were tolerant of 1 pound of each formulation when fully tillered. Data obtained from treating in the boot stage of growth indicate that the yield of one variety was reduced with 1/2 pound of each formulation, while seven varieties were tolerant of 1/2 pound of ester and 3/4 pound of amine. Barley is, in general, the most susceptible of the three crops, there is a tendency to be a varietal difference and barley, in general, appears to be less tolerant of the ester formulation than either oats or wheat. One pound of ester reduced the yields of seven varieties when applied to four stages of growth and 1 pound or less of each formulation reduced the yields of 10 varieties when applied to the 3-leaf or 5-leaf stages of growth. The yields of six varieties were reduced by applying 1/4 pound of ester and 3/4 pound of amine while the grain was heading.

In summing up the results it appears that 2,4-D may be used for the control of susceptible annual weeds before the crop is fully tillered and that this chemical may be used in sufficient quantities to control most perennial weeds after the crop is fully tillered - except for the boot stage of growth - without decreasing yields materially.

In conclusion, I would like to state that there is a need for more uniformity in reporting or treating various stages of growth. As an example, I would like to refer you to the wheat table in the summary of Project III, where the effect of 2,4-D on spring wheat, oats and barley is discussed. In that table six varieties are shown to be quite susceptible at the heading stage of growth. These were reported as being treated when "starting to head". I was at a loss as to whether these should be classified as "heading" or "boot". You will also notice that I have implied that the 3-leaf and 3-inch stages of growth are the same. I have also placed the 5-6 leaf and the 4-5 inch stages in one column. These stages would be the same in some cases, but not in others; therefore, I feel that we should attempt to gain more uniformity in our trials so that the data will be more comparable. I would also like to re-emphasize the value of statistics in evaluating data in this project and urge everyone to use this tool. I also feel that it is desirable to use weed-free grain whenever possible as it is necessary to eliminate as many varieties as possible. And finally, I would like to state that we have a good start on this project and I hope all of the investigators who have contributed this year will continue this study as we still have much to learn on this problem.

THE RESPONSE OF FLAX TO 2,4-D*

R. S. Dunham

Spraying flax with 2,4-D for the control of susceptible weeds is unquestionably one of the successful practices that has developed in the short period since its introduction as an herbicide. Just two years ago at the Des Moines Conference we classified flax among the susceptible crops "too readily injured

for selective spraying of weeds in them and readily injured by spray drift." This year 17 investigators from this Conference have contributed the results of their research with 2,4-D on flax.

I shall attempt to draw some conclusions from these reports and some research that has preceded. I have been very sincere in trying to make correct interpretations but I have had no opportunity to contact these contributors so that I must assume considerable responsibility for my remarks.

Investigators are almost unanimous in their opinion that the ester is more potent than the amine or sodium salt. It can therefore be used at smaller rates for weed killing but overdoses are more liable to cause damage to the crop. The correct dosage is not easy to determine for any formulation but it is most difficult for the ester. Rates safe for the crop and effective against weeds are influenced by the stage of growth of both crop and weeds, by the variety of flax, and perhaps by the growing conditions. Results this year indicate that flax may be sprayed earlier than was formerly recommended. If weed seeds have germinated in numbers, it seems advisable to spray early. Certainly, spraying in bud and bloom stage has proved injurious to the crop and relatively ineffective on annual weeds.

It is the duty of all of us attending this Conference to act as liaison officers between science on the one hand and the farmer on the other. For that reason we have all avoided too many technical terms. I believe, however, we are likely to be forced into much more accurate despriptions of stage of growth than we have been making when we used only height in inches.

In fact, it seems to me that the relative tolerance or susceptibility of flax may be closely associated with the development of the growing point; its location and its differentiation into leaf primordia and flower primordia.

Very little work was reported relative to varietal response to 2,4-D. At Minnesota, differences were demonstrated again but the spread between tolerant and susceptible varieties was narrower than last year, probably because of the dry spring which was not conducive to succulent growth. Likewise, at the low rates tried, differences did not show up in yields. Although yields are the ultimate measure of the effect of spraying, I believe we should be cautious about using them as our only yardstick. It is entirely possible that a susceptible variety might yield as well as a tolerant variety in a particularly favorable environment while, under adverse conditions, yields would be greatly reduced. Since we cannot predict these conditions, it seems advisable to make recommendations on the assumption that susceptibility will be expressed in the yields.

Delay in maturity was mentioned in nearly all reports. If considerable delay results from the use of 2,4-D it is a very important injury. However, an analysis of the reports shows that important delays often followed only heavy rates or applications made at susceptible stages of growth. It is important that the public is not confused by reports of what happened under the extremes of an experiment with what happened with recommended rates and dates. Since important delays have not resulted from spraying in the Minnesota

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*Division of Agronomy and Plant Genetics, University of Minnesota, St. Paul, Minnesota. Paper No. 648 of the Misc. Journal Series, Minnesota Agricultural Experiment Station.

trials, two questions arise. First, are these reported delays noted at blossom time or at maturity? It has been our experience that considerable delays at blooming have not persisted but rather have been greatly shortened by the time of harvest. Second, was the flax too late because of variety or late planting. Flax ripening too late in the season may prolong the process abnormally and any delaying effect of treatment might be exaggerated.

The pure seed grower is interested in two further aspects and the processor a third. It is important to the seed producer that 2,4-D does not injure germination and does not cause any change that would be hereditary. The processor is interested in any effect on quantity and quality of oil. Unfortunately the evidence seems inadequate at this time to answer the questions positively. Germination tests reported last year indicated no injury following applications of 2,4-D at recommended rates and stages of growth. No reports on such trials were made this year. At Minnesota all germination percentages were so low this year that no conclusions could be drawn. Trials to determine the possible influence on the genetic constitution were also made at Minnesota. There was no indication that such a change had occurred in the F_1 but it is believed that the F_2 generation should be grown before the question is answered satisfactorily. No reports on oil percentage or iodine number were received and the analyses in process at Minnesota are not available at this time.

EFFECT OF 2,4-D AS A SELECTIVE HERBICIDE ON FALL PLANTED WHEAT, OATS AND BARLEY

W. C. Elder, Oklahoma

When fall planted small grains are sown under favorable weather conditions, annual weeds usually are not a problem, especially in the southern part of the hard red winter wheat belt. A large amount of winter wheat was planted in 1947 under very dry conditions and emergence did not occur until December or the early months of 1948. Small wheat, and many times thin stands, induced a heavy infestation of winter weeds and a large crop of summer annuals in the spring of 1948. Only a small amount of 2,4-D had been used on winter wheat before 1948. This weedy wheat stimulated great interest in the use of 2,4-D as a selective herbicide.

Some 2,4-D was used throughout the entire winter wheat belt, and in certain sections large areas were treated. Kansas reports 500,000 acres of wheat sprayed in 1948. A large percent of this spraying was done with the airplane but ground units were found operating in every section.

A large percent of the applications were made not to eliminate weeds from competition with the wheat crop but to destroy large weeds that would interfere with combining. Not all of the applications were made according to our conference recommendations of 1947. Much wheat was sprayed during boot and heading stage of growth. Also a large percent was treated just prior to combining.

Effect of 2,4-D on Wheat and Other Winter Small Grains

All 1948 abstracts and reports from the dry section agree that 2,4-D had little or no effect on yield or quality of wheat unless used at excessive rates. Fortunately some experiments were conducted under favorable growing conditions

and different results were secured. Under good moisture conditions, wheat was injured with small amounts of 2,4-D at all stages of growth. The wide variation in growing conditions that apparently affect the results of 2,4-D on wheat make it difficult to correlate all data reported into one abstract.

A review of the submitted abstracts indicate certain trends that should be considered. There was close correlation of all abstracts on the effect of 2,4-D at different stages of growth. All that report injury to wheat from spring spraying agree that the boot stage is most susceptible. The least injury occurred at fully tillered stage in the spring, followed by jointing stage. Some injury was reported in all stages from early boot to headed stage. Application of 2,4-D on young wheat in fall months caused greater injury than at any other stage. All this information corresponds very closely to the 1947 results reported on winter wheat.

All reports agree that esters are more injurious to wheat than other 2,4-D formulations when used at the same rate. It seems that salt and amine formulations must be used at twice the rate of the esters to cause the same injury to wheat.

The amount of injury at definite rates are grouped according to growing conditions. Under favorable conditions some injury occurred from the use of esters at 1/4 to 1/2 pound with severe injury at 3/4 pound rate. One pound of amine produced about the same injury as 1/2 pound ester. When used at 1 pound rates, 2,4-D esters and 2,4,5-T ester cause about the same injury to wheat. In the dry sections little injury occurred to wheat under 3/4 pound of ester or 1 pound rate of amine or salts. One investigator, using an airplane for application, reports that esters used in 1 gallon of diesel oil per acre gave good coverage and was equal to 5 gallons of water. Several esters used in this experiment gave about the same results.

Some interesting facts can be observed from the reports on the effect of 2,4-D on quality of wheat and causes of reduced yields. Where wheat is injured by early treatment before bloom stage, maturity is delayed. Under severe injury maturity may be too rapid near the ripening stage. Germination was affected very little by 2,4-D treatments. Low test weight and shriveling of the kernels was reported. One investigator found that loss in wheat yields were primarily due to fewer kernels per head. Treatments made in the early boot stage also resulted in fewer spikelets per head.

This summary was to cover winter oats and barley also. However, there were no abstracts submitted for oats and only one for barley. Barley was treated at four stages of growth with salts and esters from 1/4 to 1 pound per acre. The 1 pound of ester delayed maturity when treated at the second joint stage, but there was no significant difference in yields.

No mention was made as to the response of winter grain varieties to 2,4-D. Pawnee wheat was used universally in the hard red winter wheat area. Several cooperators now have uniform tests in progress for 1949 on winter wheat varieties using a wider range of stage of growth treatments.

Effect of 2,4-D on Weeds in Winter Wheat

Several abstracts were received on the control of weeds in wheat. These reports indicate that 2,4-D can be used to kill a large number of annual weeds at rates that are not seriously injurious to wheat, especially when used in stooling

or jointing stage. Young weeds were killed with 1/4 to 1/2 pound of ester and 1/2 to 2/3 pound of salt and amine per acre. However, as the weeds increased in size, more 2,4-D was required. Some investigators reported very nice increases in yields where weeds were killed in growing wheat. Many reported that harvesting was much easier in the 2,4-D treated fields.

Unfortunately, many of the noxious perennial weeds found growing in wheat should be treated when wheat is in the most susceptible stage to 2,4-D. The large amount of 2,4-D necessary for these perennial weeds, applied at the critical stages of growth of the wheat, will usually injure wheat; however, reduced yields may not be greater than the injury from the weeds if allowed to grow.

Summary

The widespread use of 2,4-D in 1948 establishes this selective herbicide as a great aid in future weed problems in winter wheat. The reports indicate that its use this year added many bushels of wheat for the winter wheat growers and could have increased yields for many more if they had used it. Many research men in the area are concerned about the future use of 2,4-D because, first, 2,4-D will be profitable only when there is a heavy infestation of weeds. This outbreak of weeds will not occur every year. Second, applications made in 1948 in the dry section at all stages of growth may lead many to believe that 2,4-D will not injure wheat.

Before specific recommendations can be made, several factors must be considered, such as the kind of formulations used, growing conditions, size and kind of weeds and the stage of growth of the wheat when applications are made.

The abstracts would indicate that to get the most economical and maximum use from 2,4-D on annual weeds in winter wheat it should be applied in the spring while the weeds are small and before boot stage of the wheat.

THE RESPONSE OF LEGUMES SEEDED AS UNDER CROPS TO 2,4-D

John H. Miller, U.S.D.A., Minnesota

We are all aware of the important role that legumes play in maintaining and improving the qualities of our soils. The addition of nitrogen, organic matter, and improved soil structure are necessary in our crop rotations if we are to maintain our high level of crop production.

Considerable work has been done, determining the tolerance levels of many of the cereal grains to 2,4-D. We have been able to treat cereal crops with concentrations of 2,4-D that have effectively controlled most annual broadleafed types of weeds without serious injury to grain crops. This was a great step forward in the control of weeds and has resulted in a great increase in the acreage of cereal crops being treated with herbicides.

Since it is such a common practice to establish legume stands by seeding the legume with other crops, it is important that we also determine the response of such combinations of crops to 2,4-D. Legumes seeded alone have, in general, been classified as susceptible to 2,4-D, and for this reason we have been hesitant in recommending the treatment of cereal grains in which legumes have been seeded.

The lack of a positive recommendation has brought about two different conditions, the grower either omits the important legume from his rotation and treats the cereals for weed control or seeds the legume and hopes to be able to control weeds by some other means than herbicidal treatments. Should we be able to successfully treat legumes in other crops with 2,4-D sprays, it would be a great stride forward in weed control and at the same time help maintain our production level through maintaince of our soil. There are many questions that must be answered before we can arrive at a definite conclusion and recommendation. We have just begun to gather data toward this end.

We must determine the differential response of different species of legumes to 2,4-D, and in addition the differential response which may exist in varieties within a specie as has been well demonstrated in the case of flax and other crops.

We also must study the influence of the crop in which the legume is being grown, upon not only the response of legume but also the response of weed species to 2,4-D applications. At first glance, one might think that the importance of the grain crop is that it provides a means of intercepting much of the 2,4-D material before it reaches the legume. This is probably true, however, one must not lose sight of the possibility of physiological changes that may be brought about in the legume and weed species by the nurse crop such as those processes within the plant which may be affected by shade, competition for water and food materials, humidity, temperature, etc. One, several, or all of these and other factors in addition to interception by the cereal crop may be important in the response of legumes to 2,4-D when they are seeded with taller-growing crops. It is also feasible that the stage of growth of the taller crops may well influence these conditions, thus the time of application is an important question to be answered.

These comments are in no way meant as criticisms of the fine work that has been done in this field of herbicidal research, for much or all of these ideas are incorporated in the research being conducted at the present time.

The data at hand concerning these problems expressed considerable variation in results. This in itself presents us with a challenge toward more and better research in weed control. In general, the ester formulation of 2,4-D caused more damage to legumes seeded in cereal crops than did the amine or sodium salts. The sodium salt appeared to be least severe in its reaction. Unfortunately the response of weeds under like conditions was not available, thus conclusions as to their response of the different formulations could not be drawn. The observation of Buchholtz with respect to applications of the isopropyl ester of MCP to alfalfa and red clover was very interesting. With 1 pound of acid per acre he obtained a highly significant decrease in stand of alfalfa and a highly significant increase in stand of red clover. He also found considerable variation in response of red clover and alfalfa to applications of the amine salt of 2,4-D obtained from different sources. His work indicates considerable difference between red clover and alfalfa in their response to herbicidal treatments, in that red clover appears to be considerable more tolerant to 2,4-D than does alfalfa. Buchholtz was able to maintain stands of red clover and increase stands of alfalfa through applications of the di-nitro compounds, whereas Taylor and Slife and Fuelleman decreased stands of red clover with these compounds.

From a rather limited amount of data relative to concentrations of 2,4-D materials there appears to be a relationship between concentrations and time of application. Most workers were in agreement that the concentrations that could be satisfactorily used were directly related to the stage of growth of the cereal crop at the time of application. In general, the concentrations could be increased somewhat as the cereal crop increased in height and density. Buchholtz was able to successfully treat red clover with .5 pound of amine and butyl ester and with 2 pounds of sodium when the cereal crop was approximately 20 inches high without reductions in stands of red clover. Alfalfa under the same conditions, on the other hand, could withstand concentrations of only .25 pound of butyl ester and amine, and .5 pound of sodium salt without serious injury to the alfalfa stand. Slife and Fuelleman found 1/4 pound of 2,4-D to be fatal to red clover when nurse crop was 8-12 inches tall. In treatments where the grain crop was 2-3 feet tall applications of 1/4 pound of 2,4-D, while some reduction in stand was evident, did not eliminate the red clover. Leefe was able to maintain satisfactory stands of red clover with applications of 1/4 pound of sodium and 1/8 pound of amine when the grain crop was in the shooting stage of growth. The ester formulation materially reduced the stands of clover. At later dates he reduced stands of clover and did not obtain satisfactory weed control with any of the three standard 2,4-D formulations.

The number of legume species utilized in these trials was limited. Red clover was used by all the workers that submitted reports. Buchholtz included alfalfa, and Miller included biennial sweet clover. Contrasted to Buchholtz' observations in differential response between red clover and alfalfa, Miller could observe little, if any, difference in the response of red clover and biennial sweet clover.

Little can be concluded with respect to weed control as much of the work was conducted on relatively weed free areas. Leefe satisfactorily controlled wild radish with early applications as low as 1/8 pound of all three 2,4-D formulations, however, applications at later dates did not result in favorable weed control even with concentrations of 1/2 and 3/4 pounds of 2,4-D. Miller did not obtain satisfactory control of small ragweed, lambsquarter or cocklebur with concentrations of 1/4 pound of 2,4-D regardless of the stage of development of the cereal crop at the time of application. However, it should be noted that the abnormally dry conditions that prevailed in the St. Paul area appeared to cause most species of weeds to be more tolerant to 2,4-D treatments than was normally expected.

In a summary of the observations made to date, one may conclude that we are still in an embryonic stage of development in obtaining the answers to this important problem. Many questions are still unanswered and it appears that one must proceed with caution when applying 2,4-D to legumes seeded in other crops until more work has been done.

EFFECT OF 2,4-D AS A SELECTIVE HERBICIDE IN PERENNIAL GRASSES

Glenn Viehmeyer, Nebraska

It seems evident from abstracts submitted, from previous work reported and from reports of those now using the herbicide in the field, that perennial grasses are, as a crop, particularly suited to the use of 2,4-D as a herbicide. Since cultivation is out of the question in a sod crop, weed control in such

crops is limited to chemical control, mowing or to a combination of the two. Perennial grasses, as a class, are among the most 2,4-D tolerant crops. They are, as a rule, little affected by the dosages of 2,4-D needed to control most broad-leaved weeds that commonly infest them. While differences in tolerance between species and between strains within a specie exist, such differences are in general of minor importance since they do not appear except at dosages far higher than those necessary to control weeds.

From the evidence available, both that submitted by cooperators in abstracts, and that secured from other sources, the most serious limitation of 2,4-D as a herbicide in grasscrops appears to be its inability to control the weedy annual grasses. These plants seem to have a degree of tolerance for the herbicide equal to that of their perennial relatives and a study of the reports of those working with the grasses indicates that 2,4-D is no answer to the control of weedy grasses. Indeed such workers agree that, under conditions of heavy infestation of grassy weeds much of the value of 2,4-D is nullified and that in case of extremely heavy infestation its use may even be detrimental to young perennial grasses. Removal of the broad-leaved weeds from mixed weed populations frees annual grasses from competition and their more rapid rate of development enables them to outgrow and suppress slower growing perennial species.

From the information at hand it seems that the problem falls into three classifications that should be considered separately. They are, (1) established stands of grass, (2) seedling cool season grasses, (3) seedling warm season grasses.

Chemical weed control in established stands of either warm or cool season is now a matter of record. Once well established, most species of grass are so tolerant of 2,4-D that control is simply a matter of using a dosage high enough to control the weed or weeds in question.

Likewise, control of weeds in new plantings of cool season grasses presents no particular problem if proper precautions are taken. Cool season grasses can and perhaps should be planted in the fall, if this is done on a well prepared seedbed with sufficient soil moisture seedlings will be well established before weed competition develops. Even where it is necessary to plant in the spring, such planting can be done early enough to permit the grass seedling to start before weed competition reaches a peak, and to reach a size where comparatively heavy dosages of 2,4-D are possible without danger to the grass.

Reports from cooperators indicate that weed control in newly seeded warm season grasses is complicated by a number of factors not found in the case of seedling cool season grasses or in established stands. Most of these special problems may be correlated with the fact that warm season species are planted at a time when weed germination and emergence is at a peak. As a result weed competition is often critical and stands may be lost.

In summing up, most investigators agree that warm season grasses should be planted in soil as free of weed seed as possible and that fields badly infested with seed of annual grasses should not be planted until the infestation is cleaned up. Warm season grasses are quite tolerant of 2,4-D in dosages sufficient to control broad-leaved weeds but that supplementary measures such

as mowing may be required if annual grasses form an appreciable percentage of the weed population.

In one case mowing and 2,4-D is reported as giving better control than either 2,4-D or mowing alone where mixed populations were present. Plots receiving the combination treatment giving better yields as measured by amount of top growth than those receiving either 2,4-D or mowing alone.

Attempts at weed control by use of pre-emergence treatment have proven unsatisfactory due to failure of grass seed to germinate well following such treatment.

Preplanting treatments appear to have promise under some conditions if applied far enough ahead of planting. Such treatments have the added advantage of giving a high degree of control of both grassy and broad-leaved weeds. However, much is to be learned about pre-planting treatments before they can be recommended for general use. In fact more information regarding the response of grass crops to 2,4-D is needed before this herbicide can be fully utilized for weed control in grass crops.

Wednesday afternoon, December 8

ABRAHAM LINCOLN HOTEL BALLROOM

SECTION II - HORTICULTURAL CROPS

CHAIRMAN, B. H. GRIGSBY

CERTAIN PHENOLIC COMPOUNDS FOR RESIDUAL PRE-EMERGENCE WEED CONTROL IN HORTICULTURAL CROPS

Keith C. Barrons, Wendell R. Mullison, C. D. Fitzgerald and L. L. Coulter, The Dow Chemical Company

Residual dosages of certain phenolic compounds have been used commercially as post-emergence treatments between the row in sugar cane and pineapple to prevent the emergence of weeds that normally germinate near the surface. Recent experiments indicate that these materials may be used as residual pre-emergence treatments on such large-seeded field crops as cotton, corn, and soybeans without undue risk. In 1948 the writers explored the possibilities of utilizing phenolic compounds as residual pre-emergence treatments with a wide variety of crops including many of interest to horticulturists. It is hoped this preliminary report will suggest chemicals and techniques for further trial by horticulturists on those species which are likely to tolerate residual pre-emergence treatment.

WEED CONTROL TERMINOLOGY

Pre-emergence chemical weed control is usually considered to involve the application of herbicides after seeding the crop but before crop emergence. Reference is thus made to the crop and not to the weeds which may or may not be up depending on the method used. In a recent review[1] of the status of pre-emergence spraying the following classification was suggested:

[1] Barrons, Keith C. Pre-emergence Weed Control Down to Earth Vol. 4 (No. 3) pp. - 2-4 1948

(1) Contact Pre-emergence; the killing of tiny weeds that emerge before the crop with non-residual dosages of contact-type sprays. This method has proved valuable with certain slow-germinating small-seeded crops that will not tolerate residual dosages. (2) Residual pre-emergence; the killing of weed seeds and germinating seedlings with dosages that result in toxic concentrations in the surface soil. It must be recognized that if application is delayed long after seedling some tiny weeds may be up and both a contact and a residual action will be required.

Two related methods which involve the same herbicides but are not strictly speaking pre-emergence methods are recognized. (1) Pre-planting treatment; the application of herbicides, usually of the contact type, before seeding with no reworking of the soil. This method has proved useful with fast-germinating crops that will not tolerate residual dosages. A seeder that gives a minimum stirring of the soil must be used. (2) Post-emergence residual treatment; application to the soil between the rows of established crops to prevent late germination of weed seeds as earlier mentioned for sugar cane and pineapple.

Chemicals and Methods Used

The seed beds were prepared for planting in accordance with usual farm practices. The seeds were planted by a planter at the customary depths for these crops. (Table 1) Water dispersions of the chemicals were sprayed on the soil after seeding. In most cases this was immediately after seeding.

Pentachlorophenol (PCP) and 4,6 dinitro-o-sec-butylphenol (DNOSBP) in emulsifiable oil formulations were used in these tests and also the water soluble sodium salt of PCP and the ammonium salt of DNOSBP. Rates up to 40 pounds of toxicant per acre were employed in comparative tests.

Weed Control Results

Many species of common annual weeds including both grasses and non-grasses were controlled. Because some annuals escaped even at the higher rates it appears unlikely from these tests that cultivation can be completely eliminated. Weed control was adequate, except with the lower rates employed, to permit elimination of the first cultivation. Perennial weeds were not controlled by this method nor were certain large-seeded annuals.

Average results indicated that from 15 to 25 pounds per acre of PCP or its sodium salt or from 5 to 8 pounds per acre of DNOSBP or its ammonium salt are needed for good weed control. This range in rates is suggested for further trial. For application only over the row one third these amounts may be used.

On the average, application at the time of seeding gave as good results as delayed treatment. Possibly delayed spraying would have value on slow emerging crops. Treatment at the time of seeding permits combining the two operations and insures completion of the program without interference by prolonged rainy weather which may upset a schedule calling for application shortly before emergence.

Surface moisture was observed to be essential to success. Poor results with one set of plots on a poorly prepared lumpy seed bed emphasized the fact that a well pulverized and compacted seed bed is desirable.

The Tolerance of Several Crops to Some Phenolic Compounds

Several field plot tests were made on numerous species in the spring and fall of 1948 using certain phenolic herbicides for pre-emergence weed control. The results of these experiments are summarized in the following table.

TABLE I TOLERANCE OF VARIOUS HORTICULTURAL PLANTS AND SEEDS TO RESIDUAL PRE-EMERGENCE WEED CONTROL TREATMENTS WITH CERTAIN PHENOLIC HERBICIDES

Plant Tested	PCP 15 lb./ acre	DNOSBP 5 lb./ acre	NH_4 salt of DNOSBP 5 lbs./acre
Potatoes	0*	0*	0*
Gladiolus	0	0	0
Corn	0	0	0
Sunflower	0	1	0
Muskmelon	0	0	0
Watermelon	0	0	1
Squash	0	0	0
Cucumber	0	0	0
Lima bean	0	0	0
Red kidney bean	0	0	0
Snap bean	0	0	0
Pea	0	0	0
Cabbage	2	3	3
Lettuce	3	3	3
Carrot	3	3	2
Radish	3	3	3
Kohl rabi	3	3	3
Swiss chard	2	3	2
Beet	2	3	3
Spinach	3	3	3
Onion	3	3	3
Endive	3	3	3
Nasturtium	0	0	0

*0 no reduction in stand
1 slight reduction in stand
2 marked reduction in stand
3 complete or almost complete absence of stand

Results of further exploratory work under farm conditions with respect to crop tolerance follow:

Peas Canning peas seeded at a 1½ to 2 inch depth were sprayed with the four materials previously listed at two locations and on two dates. Neither 10 pounds or less of DNOSBP and its ammonium salt nor 30 pounds or less of PCP and its sodium salt caused a reduction in stand. Higher rates caused some stand reduction and retardation of growth particularly in one test. In this instance heavy rains followed application. At 30 pounds per acre PCP and its salt caused a slight reduction in vigor in this test but at the 20 pound rate no crop effect was noted.

Beans PCP and its sodium salt were applied at 10, 20, and 30 pounds per acre and DNOSBP and its ammonium salt at 3, 6 and 9 pounds per acre in two tests on Thoroughgreen Lima bean, one of Michelite field bean and one on Tendergreen snapbean. No crop injury was noted on the lima or field beans at any time. At the highest rate of the sodium salt of PCP a slight chlorosis of the primary leaves was observed with an occasional necrotic lesion on the margins. At the highest rate of the ammonium salt of DNOSBP the chlorosis was not observed but marginal necrosis occured more frequently. In neither case was the subsequent growth of the beans impaired. The toxic effect appeared to be localized and acute in nature.

Sweet Corn Golden Cross Bantam was treated with the same materials and rates as the beans. Necrotic lesions were observed on the primary leaves of an occasional plant treated with the highest rates of all materials. No indications of systemic toxicity were observed. Corn in the plots receiving the highest dosages grew as well as that in the untreated check.

Asparagus Plots of established asparagus were sprayed with the sodium salt of PCP and the ammonium salt of DNOSBP immediately following the post-cutting discing in early July. The highest rate used of the former (20 pounds per acre) and the highest of the latter (10 pounds per acre) provided satisfactory annual weed control throughout the remainder of the season. No evidence of injury was observed at any time following treatment.

Discussion

It will be noted from table 1 that all the large-seeded crops tolerated pre-emergence treatments with phenolic herbicides while the stands of most small-seeded crops were reduced. Planting depths were those ordinarily used for the crops involved. It appears from these results that depth protection of the germinating seed is the primary factor involved in the selective action of these chemicals although physiological differences in response may sometimes be involved. Apparently because of their cuticle the epicotyl, cotyledons and hypocotyl do not absorb enough toxicant from the soil to cause injury except at high rates of application. Non-lethal injury from excessive rates of these phenolics tends to be localized and non-systemic resulting in no adverse effect upon subsequent growth.

When the application was delayed long after seeding some quick-emerging weeds were up at the time of treatment. These were killed with the emulsions but in some instances the salts did not give a good kill apparently because of a lack of complete contact action. If the salts are used for delayed application when some weeds are already up miscible oil should be added to insure good wetting and penetration.

Tests of DNOSBP in varying amounts of oil indicated that the oil was not a factor in effectiveness when this compound is used strictly as a residual pre-emergence spray. Where contact action is needed on emerged weeds oil would be an important factor.

Limited comparisons on corn indicated that the phenolic compounds at the suggested rates may give annual weed control equal to that provided with 2,4-D. With many crops there would undoubtedly be less risk from the phenolics than from 2,4-D and even on corn they are definitely worth further trial. Preliminary tests on corn with mixtures of some phenolics with 2,4-D gave promising results.

DNOSBP and its ammonium salt were found to be considerably more phytotoxic pound for pound than PCP and its sodium salt when used as residual pre-emergence herbicides just as they are when used as foliar sprays. On some species, i.e., lambsquarters and crabgrass, the ammonium salt of DNOSBP appeared to be fully four times as effective as the sodium salt of PCP. Pigweed and lady's thumb were relatively more sensitive to the latter. On these species the ammonium salt of DNOSBP was about twice as effective as the sodium salt of PCP.

The water soluble salts frequently but not always appeared to be more effective than the corresponding parent phenols. Further work will be required before it is known whether the parent phenols or their salts are most satisfactory under average conditions. Possibly the salts are more readily distributed in the soil solution, which might be an advantage when moisture is not abundant and a disadvantage if heavy rainfall followed application particularly on sandy soil. Possibly crops planted as shallow as 1 inch would tolerate such a treatment on soils that do not permit rapid leaching. Crop tolerance, weed susceptibility to the different materials and chemical costs will all have to be considered. The effect of soil variables including physical and chemical properties as well as organic matter, moisture and temperature will require further study.

Many plants propagated from tubers, bulbs, root divisions and corns could probably be treated safely. It appears likely from the results of these tests that other crops which may be planted at a depth of $1\frac{1}{2}$ inches or more will tolerate residual pre-emergence phenolic herbicides. Early spring pre-emergence applications to established perennials including asparagus and peonies are definitely worth trial. The phenolic compounds are also promising for post-emergence or post-planting residual soil treatment of long season crops and nursery stock to prevent annual weed growth between the row.

Where these phenolic compounds have been repeatedly used on the soil no evidence of accumulative or permanent toxicity has been noted. To what extent these materials are lost through volatilization, leaching and decomposition is not definitely known. Some phenolic compounds are known to be decomposed by soil microorganizms[2].

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[2]Geultoneau, G. and R. Chevalier Utilization of phenol compounds as sources of energy by the azotobacter of the soil.
Soil Science Society of Amer. Proc. 4:237 1939

Conclusions

1. Residual pre-emergence weed control in several horticultural crops was obtained by spraying the soil with formulations of pentachlorophenol, and its sodium salt, 4,6-dinitro-o-sec-butylphenol, and its ammonium salt.

2. Small seeded crops such as lettuce, onions, etc., planted at shallow depths were injured by residual pre-emergence sprays and in general seem not to be adapted to this type of weed control.

3. Large seeded crops such as peas, beans, squash, watermelon, etc., which are generally planted at depths of 1½ inches or more seem to be most suited for residual pre-emergence weed control.

4. Potatoes and gladioli are examples of crops propagated vegetatively where the weeds were successfully controlled by this method without injury.

5. Residual pre-emergence weed control also proved successful with established asparagus.

6. This method is suggested for farm trial. Further research is necessary before it should be recommended for general use.

PRE-EMERGENCE TREATMENTS FOR ONIONS, LIMA BEANS, BEETS AND ASPARAGUS

G. F. Warren, University of Wisconsin

The lack of suitable selective weed sprays for many vegetable crops has led to the study of weed control by various pre-emergence treatments. An attempt will be made to summarize some of the studies made on this subject at the University of Wisconsin during the past four years.

Onions

Work with pre-emergence treatments on onions grown on peat soil has indicated that they may be valuable in one or more of the following ways:

1. Reduce cost of weeding and cultivating.
2. Increase yield by reducing early weed competition.
3. Give more time to get weeding done.
4. Improve results obtained with post-emergence selective sprays by allowing crop to become larger and thus more tolerant of chemicals before weeds are too large to be killed.
5. Kill many weeds that are not controlled by selective sprays. In Wisconsin, for example, we have found that most of the lamb's-quarters, which is hard to kill with present selective sprays, germinates early and is controlled by a good pre-emergence spray.

In our experiments with onions we have investigated the use of the following two types of treatments:

1. Contact. The use of an herbicide that would kill all weeds that had emerged when the spray was applied yet have little or no residual effect. Oils, dinitros and light doses of 2,4-D were tried.

2 Contact plus residual. Here we were interested in killing not only the weeds that had emerged but also those that germinated during the few weeks after the application. For this, 2,4-D at rates from 1 to 8 pounds was the principal herbicide tried.

The contact type of herbicides were applied from one to two days before onion emergence in all experiments. The fields had all been fitted immediately prior to planting. Weed control varied considerably in the different fields depending primarily on the proportion of the weeds emerged at the time sprays were applied but the reduction in number at the time of the normal first hand weeding averaged approximately 50 per cent. Nearly all materials tried caused serious reductions in the stand and yield of onions at some rates of application under some conditons. However, by the right choice of materials and by carefully controlling the rate of application the danger of injury to the onions was largely eliminated.

The safest pre-emergence spray of those tried was Stoddard solvent since it is highly volatile and even at excessive rates caused only slight injury to the onions. The appropriate rate of application appears to be somewhat over 50 gallons per acre which makes this material expensive unless the quantity used is reduced by confining the spray to a narrow strip over the row. Diesel fuel at 30 to 40 gallons per acre and the sodium or amine salts of 2,4-D at 1/2 pound of acid equivalent per acre have given good weed control and have caused little or no injury to onions on peat soil. They are considerably cheaper than Stoddard solvent but have often caused injury at higher rates of application. The choice between the use of an oil or 2,4-D may depend in part on weather conditions and the kind of weeds present. For example, in rainy weather or where there are a large number of smartweeds (Polygonum spp.) which are resistant to 2,4-D, one of the oils would probably do a better job. With favorable weather and susceptible weeds, 2,4-D may give better weed control and due to its low cost would probably be preferable. Dow Contact (a dinitro) severly injured the onions in several experiments at the lowest rates of application that gave good weed control and, therefore, was unsatisfactory.

Over 200 acres of onions on peat soil were given pre-emergence sprays in Wisconsin in 1948 with light rates of 2,4-D, diesel fuel or Stoddard solvent. The growers in all cases were well pleased with the results. It should be pointed out, however, that grower experience was not favorable in the previous year. Use of the wrong materials or too heavy rates of applications resulted in severe onion injury in several cases. Promising as the contact type of pre-emergence treatment is for onions, it should be tried cautiously at first by the inexperienced grower.

Our work with the contact plus residual type of treatment on onions has been extensive, some 20 replicated experiments have been conducted during the past four years. Since the results of much of this work have been published in detail elsewhere[1] only a summary of our findings will be presented here.

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[1] Warren, G. F., Buchholtz, K. P., and Hernandez, T. P. Preliminary studies on the effects of soil applications of 2,4-D on crop and weed growth. Proc. Amer. Soc. Hort. Sci. 50:373-382 1947.
Warren, G. F. and Hernandez, T. P. Weed control in certain vegetable crops with soil applications of 2,4-D. Proc. Amer. Soc. Hort. Sci. 51:515-525. 1948.

When 2,4-D was used at rates of one pound or more per acre many weeds that had not emerged were controlled in addition to those that were already showing above ground when the sprays were applied. The reduction, compared with the checks, in number of weeds at the time of the first weeding has averaged about 70 per cent for one pound of 2,4-D acid equivalent and has increased as the rate of application increased. Since the weeds remaining were mostly stunted these treatments effectively eliminated the first hand weeding.

Onion stand and yield has sometimes been unaffected by as much as 4 pounds of 2,4-D per acre while in other experiments 2 pounds caused considerable injury and in one commercial trail 1½ pounds resulted in excessive damage. Some of the factors that apparently affected the amount of damage to the onions are as follows:

1. Rainfall. Injury was more severe when heavy rains occurred soon after treatments were applied.

2. Drainage. Injury was greater on poorly-drained peat soils than on well-drained ones.

3. Time of application. Less injury resulted when the sprays were applied just before onion emergence than when applied earlier. Weed control was similar.

4. Formulation. The sodium and amine salts gave practically identical results but the esters often caused severe injury to the onions while giving only slightly better weed control.

5. Depth of planting. Deep planting (approximately 1 inch) may reduce the danger of injury but evidence is insufficient on this point.

The two varieties used, Early Yellow Globe and Brigham Yellow Globe, showed no difference in response to 2,4-D and storage data showed no effect of the treatments on keeping quality.

It should be emphasized that all of this work was done on peat soil. Mr. T. P. Hernandez has reported results of work done in Wisconsin, which appear elsewhere in these Proceedings, showing that 2,4-D caused excessive damage to onions grown from both seed and sets on a silt loam soil whereas on adjacent peat soil with the same treatments and dates of application there was no significant reduction in yield of onions for any 2,4-D treatment. In green house studies he found that 2,4-D is far more readily leached in mineral soils of low organic matter content than in peat soil. These results indicate that the use of 2,4-D on onions grown on mineral soil would be extremely hazardous.

In conclusion it may be said that the contact type of pre-emergence treatments on onions grown on peat soil appear definitely promising but the use of 2,4-D at rates sufficient to give considerable residual effect (one pound or more) is more hazardous and should not be tried on a commercial scale at the present time.

Lima Beans

In a replicated experiment in 1948, several pre-emergence treatments were tried on Henderson Bush lima beans planted 2 inches deep in a silt loam soil.

The field was fitted immediately before, and the sprays applied the day after planting so all effects on the weeds were of the residual type. The most promising treatments were the sodium salt of 2,4-D at 1 and 2 pounds per acre of acid equivalent and the sodium salt of PCP at 25 pounds per acre. These gave good control of pigweed (Amaranthus retroflexus), purslane (Portulaca oleracea) and witchgrass (Panicum capillare) but only fair control of foxtail (Setaria spp.). Dow Selective at 6 gallons per acre gave less weed control and since it is more expensive appeared less promising. None of these treatments reduced the yield of lima beans but 1 and 2 pounds of 2,4-D reduced the stand by 8 and 14 per cent respectively.

The ammonium salt of TCA at 5 and 10 pounds per acre of acid equivalent gave little or no control of the broad-leaved weeds but did an excellent job of controlling the two annual grasses present. These treatments did not reduce the stand of beans but the plants were severely stunted throughout the season and a complete crop failure resulted. A combination treatment of 10 pounds of TCA and 1 pound of 2,4-D was also included and gave almost perfect control of all weeds present. Although it could not be used on lima beans due to the injury from TCA, the excellent weed control obtained with this combination of herbicides would seem to justify its trial on other crops.

Several canning companies in Wisconsin tried 2,4-D on lima beans in 1948 with favorable results. However, neither in our experiment nor in any of those conducted by the canning companies was there a heavy rain for several weeks after the treatments were applied. It may be that with heavy rainfall 2,4-D or PCP would cause severe injury to the lima beans. It should also be noted that one experiment was observed where rainfall was so light that 2,4-D as well as all other treatments gave no weed control.

In conclusion, it would seem that both 2,4-D and PCP show sufficient promise on lima beans to deserve further experimentation.

Red Beets

A replicated experiment was conducted on a dark-colored sandy loam soil in 1948 in a field that had been fitted on May 22. On June 14 alternate strips were fitted again, while the other strips were left undisturbed. The entire field was planted with Perfected Detroit beets immediately afterward with a Planet Jr. seeder. The next day, Stoddard solvent at 100 gallons per acre, diesel fuel at 25 and 50 gallons, a 2 per cent solution of Dow Contact at 50 gallons, PCP in an oil-in-water emulsion at 2 and 4 pounds per acre and the sodium salt of 2,4-D at 1/2 pound of acid equivalent were applied as sprays to plots in both series of strips.

There was practically no rainfall between May 22 and June 14, therefore, weed growth on the undisturbed strips was light and consisted of a mixture of several annual and perennial broad-leaved weeds and a few annual grasses. There were a few good showers soon after planting the beets and another and heavier crop of weeds emerged consisting of over half purslane and the balance miscellaneous annual weeds.

Control of the annual weeds already up in the undisturbed strips when treatments were made ranged from 67 to 97 per cent for the various treatments except the 25 gallons of diesel fuel which gave less than 40 per cent control.

Only two of the treatments, however, had any effect on the weeds that started after planting the beets. One of these was 2,4-D which killed over 80 per cent of both the weeds and the beets and the other was the 4 pound rate of PCP which gave a 43 per cent reduction in this crop of weeds. The latter treatment caused some early stunting of the beets but they recovered and the stand and yield were not affected.

None of the other treatments in either the undisturbed strips or in those that were fitted just before planting gave any reduction in weeds as compared with the check plots that had been fitted just before planting. In addition it should be mentioned that perennial weeds were kept under better control on the freshly fitted check plots than on any of those that were left undisturbed and sprayed with the various herbicides.

It can be concluded that the use of contact herbicides in conjunction with planting in undisturbed soil was of no value in the production of beets under the conditions of this experiment. Results, of course, might have been quite different in other situations. The residual effect of PCP observed in this experiment may be worthy of further investigation.

Because grasses require only about one-tenth as much boron as do beets, experimental work was begun in 1942 by Dr. K. C. Berger[2] to determine if borax in bands beside the row would control grass weeds, not seriously reduce the stand of beets, and at the same time supply the borax needed by the beets for healthy growth.

The results of six experiments show that with borax placed in two bands one inch to the side and slightly below the beet seed, 25 pounds per acre supplied the boron needed for healthy growth of the beets, rarely reduced the stand and gave from 30 to 60 per cent control of annual grasses and of many annual broad-leaved weeds as well. Increasing the borax application to 40 pounds per acre reduced the stand of beets 10 to 20 per cent, gave from 50 to 80 per cent weed control and stunted the remaining annual weeds. Higher rates of borax up to 100 pounds per acre reduced the stand of beets still more and gave only slightly better weed control.

Dr. Berger believes that borax applied in this way, at rates of from 25 to 40 pounds per acre, will greatly reduce the cost of weeding beets. The lighter rate is used on sandy soil. The seeding rate should be increased about 15 to 25 per cent to compensate for the reduction in stand.

Asparagus

Excessive weed growth often makes it necessary to work up an asparagus bed during the cutting season. This results in the loss of at least one or two cuttings. Any measure which would control these weeds without the necessity of sacrificing part of the crop would be extremely valuable. Various forms of cyanamide have been used commercially for this purpose with some success and more recently 2,4-D has been tried to a limited extent.

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[2] Soils Department, University of Wisconsin, Madison, Wis.

In 1947, Mr. T. P. Hernandez[3] started a replicated experiment to compare these two materials for weed control in asparagus. The experiment was located in an eight-year-old bed on a silt loam soil near Madison, Wisconsin. The treatments consisted of 4 pounds per acre of 2,4-D acid equivalent as the sodium salt applied as an aqueous spray to the soil surface the last week in April just after discing the field and 375 pounds of granular cyanamide per acre concentrated in an 18 inch band over the row (rows 4 feet apart) when the weeds were 2 to 3 inches high. Ammonium nitrate was added to the check plots and to those treated with 2,4-D to give the same amount of nitrogen as supplied by cyanamide. The experiment was continued in 1948 repeating these same treatments on the same plots. Yield records were taken in both seasons on 5 harvests scattered throughout the cutting season.

Both treatments gave good control of annual weeds early in the season, control being slightly better for 2,4-D than for cyanamide. By the end of the cutting season a large number of weeds had started in the treated plots but they were so small as to be of no importance since, as is the common commercial practice, the bed was disced at this time. Neither of the treatments affected the yield or appearance of the asparagus spears as compared with the checks in either year. Likewise, no injury could be seen after the cutting season was over and the asparagus had "ferned out". An unreplicated experiment in another field also showed no injury in either year. Although it has not been given sufficient trial in Wisconsin, workers in other states have reported good results with a second application of these herbicides after working up the bed at the end of the cutting season.

The results of weed control experiments in other crops indicate that a lower rate of application of 2,4-D would probably give sufficient weed control and there would be less possibility of any injury to the asparagus. Commercial trials were made in two Wisconsin fields in 1948 using 2 pounds per acre of 2,4-D. The asparagus was not injured in either case and weed control was good in one field. In the other, control was poor probably due to dry weather after treatment.

Although further experimental work is needed, it appears that a pre-emergence treatment of 2,4-D might be used to good advantage in controlling weeds in asparagus. As to whether or not it will prove better than cyanamide will depend on relative effectiveness under variable conditions as well as relative cost and other factors.

Conclusions

Certain pre-emergence treatments appear promising for the control of annual weeds in onions, lima beans, beets, and asparagus. Some of these treatments may be ready for small commercial trials but the others are still in the experimental stage.

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[3] Formerly at the University of Wisconsin. Now located at Louisiana State University, Baton Rouge, La.

CHEMICAL CONTROL OF WEEDS IN ONIONS BY POST-EMERGENCE SPRAYS*

R. E. Nylund, Univ. of Minnesota

The control of weeds has always constituted the major item in the cost of production of onions. The labor shortage and high labor costs during and since World War II have increased these weeding costs so that at the present time, according to estimates by a number of Minnesota growers, the cost of weeding muckland onions ranges from $85 to $135 per acre. This situation has led to an increased interest in the possibilities of using selective herbicides to control weeds in growing onions and thus cut production costs.

As early as 1896, Bonnet had discovered the selectivity of sulphuric acid for cereal crops (2), and in 1911 Rabate (8) initiated work on the use of dilute sulphuric acid for weed control in cereals. Since Ball and French (2), in 1935, reported that a 10% sulphuric acid solution would control knotweed in onions without serious injury to the onion plants, this treatment has been recommended in England (3,9) and in New Zealand (1). In 1942, Newhall et.al. (7) showed that a 2 to 3% solution of sulphuric acid would give satisfactory control of such weeds as red-root pigweed, ragweed, shepherd's purse, and lady's thumb smartweed but that lambsquarters, purslane, and various annual grasses were resistant to its action. Other workers (4,10) have also reported similar results. However, in spite of its cheapness, the failure of sulphuric acid to control such common muckland weeds as lambsquarters and purslane, the difficulties of obtaining suitable application equipment, and the dangers involved in handling sulphuric acid have led to a continued search for more satisfactory selective weedicides for onions. Westgate and Raynor (11) in California have used Sinox (sodium dinitro-ortho-cresylate) successfully for weeding transplanted onions but reported serious damage from its use with seeded onions. Warren (10) reported injury to seeded onions from the use of Sinox while Wain (9), in England, has reported that Sinox was equally as effective as 10% sulphuric acid. A saturated solution of sodium chloride has been reported (4,5,10) to give a fair to good control of most common muckland weeds with the exception of lambsquarters. Chappell (4) and Hedlin (6) have reported satisfactory control of such common muckland weeds as chickweed, and red-root pigweed through the application of 50 pounds of cyanamid dust per acre. Hedlin (6) has also reported that a 1 to 2% solution of potassium cyanate satisfactorily controlled pigweed and such sulphuric acid-resistant weeds as purslane and lambsquarters and also gave fair control of grasses.

At Minnesota, experiments on the use of chemicals for the control of weeds in onions were begun in 1945. To the present some seventeen materials have been tested, some at several concentrations each. Chemicals such as various petroleum oils, 2,4 D, Sinox, and Dow Selective, have been discarded on the basis of either excessive toxicity to onions or lack of toxicity to common muckland weeds. In all the tests 3% sulphuric acid has been used as a standard for comparison as it has consistently given good weed control with little or no injury to onions. During the past two years a number of phenolic compounds: sodium orthophenylphenate, sodium-2-chloro-4-phenylphenate, sodium 2,4,5 trichlorphenate, sodium 2,3,4,6 tetrachlorphenate, and sodium pentachlorphenate,

*Miscellaneous Journal Series Paper No. 649 of the Minnesota Agricultural Experiment Station, University Farm, St. Paul 1, Minnesota.

have been tested in several concentrations each. Also, during the summer of 1948 potassium cyanate at several concentrations was included for the first time in our tests.

I would like to discuss briefly the results of our past summer's work on post-emergence onion weed control. Sixteen treatments were applied to onions in the one-leaf stage on May 24, one month after seeding. The treatments included 3% sulphuric acid, 25% sodium chloride, 25% potassium chloride, and potassium cyanate, sodium orthophenylphenate, sodium trichlorphenate, and sodium tetrachlorphenate at several concentrations each. Each of these treatments, applied at 100 gallons per acre, were applied to rod-row plots in sixteen randomized blocks. The air temperature at the time of spraying was 70°F. and the soil was dry, no appreciable quantity of rain having fallen in the preceding twenty days. Only four of the treatments applied at this time significantly reduced the weed population. These were: 3% sulphuric acid, 1½% sodium trichlorphenate, 2% sodium trichlorphenate, and 2% potassium cyanate. The weed population under these treatments had been reduced to 34%, 40%, 23%, and 60% of the check, respectively. Yield data obtained at harvest showed that none of these treatments had significantly reduced stands and yields of onions. Since none of the sixteen treatments had visibly injured the onion plants, a second treatment was applied to eight of the sixteen replications one week later. The concentration of most of the chemicals was doubled for this application. The air temperature at the time of the second application was 80°F. and the soil was still dry, no rain having fallen in the interval. Weed counts taken after this second series of treatments showed that all treatments, with the exception of 25% potassium chloride had significantly reduced the weed population. A number of them also significantly reduced stands and yields of onions. Some of the results are interesting. The second application of 3% sulphuric acid further reduced weed population without reducing yields, as did the 2% potassium cyanate and 1½% sodium trichlorphenate. However, the 2% sodium trichlorphenate, when repeated, significantly reduced both numbers of weeds and yields of onions. Also, 1½% sodium tetrachlorphenate, which in one application had failed to kill weeds, when applied to plots which had previously received a 3/4% solution significantly reduced weed population without injuring the crop plants. And 25% sodium chloride which had had no effect on weeds when applied on May 24 was very effective in controlling weeds when applied a second time one week later.

Since 3% sulphuric acid, 2% potassium cyanate, and 2% sodium trichlorphenate had been effective in controlling weeds without injuring the crop plants when applied once, these materials were tried again at the same rates to a later seeding of onions in the same field. This seeding was made on June 9 and the sprays applied on July 2, at which time the onions were approximately the same size as at the time of spraying in the first experiment. The air temperature was 5°F. higher than at the time of the first spraying in the first experiment, but the soil was somewhat more moist. In this experiment, all three of the treatments--sulphuric acid, potassium cyanate, and sodium trichlorphenate--were toxic to onion plants and seriously reduced stands.

On the basis of these results and similar results with other chemicals, in other tests, it is apparent that the sensitivity of the onion plant to chemicals is a rather widely fluctuating variable. Which environmental factors or combinations of environmental factors play a part in determining the resistance of an

onion plant to the action of chemicals? How do these environmental factors change the physiological or morphological characters of the onion plant so as to affect its sensitivity to a chemical? Until we know the answers to these questions, finding a selective weedicide for onions which we can recommend as being both safe to use and effective under a wide variety of environmental conditions may be a difficult task. To my knowledge, at the present time we have no such weedicide for onions.

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POTASSIUM CYANATE AS A WEED CONTROL CHEMICAL FOR ONIONS

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ABSTRACT

Potassium cyanate was satisfactory as a control weed chemical when applied to early yellow Globe onions at rates of 20 and 25 pounds per acre. Single applications should be applied at the rate of 10 pounds per acre. Onions may be sprayed while they are in the cotyledon or "loop" stage without injury to the stand. Second applications should not be made until the onions have two or three true leaves.

Several chemical materials have been used to control weeds in onions. Each of these herbicides have some property which tends to make them undesirable. Sulfuric acid is dangerous to use and corrosive even though it is inexpensive. Calcium cyanamid dust is effective, but fair weather conditions must prevail for at least three days after application. In the search for new materials, Hedlin (1) reported that potassium cyanate (KOCN) gave promise of being effective for controlling weeds in onions. The experiment reported here gives additional information on the tolerance of the onion crop for this material.

Procedure

Early yellow Globe onions were seeded April 29th in an acid mucksoil (ph.5.2) on which 1000 pounds per acre of 0-10-20 fertilizer had been broadcast and disced in. The onions began to emerge May 9th and while still in the cotyledon or "loop" stage, were treated for the first time on May 17th with three rates of applications of KOCN. The first counts on weed stand were made May 27th, and on June 3rd when the onions were in the three-leaf stage, the second treatments were applied. The effect of this second treatment was shown by weed counts made on June 12th.

Because of prolonged rainy weather the first hand weeding of the check plots could not be made until June 18th. On June 25th, 1200# per acre of an 8-8-8 fertilizer was broadcast over the onions and cultivated in.

On July 12th the weeds in all plots were large enough to again warrant hand weeding. Records of the time required for the hand weeding were kept as a measure of the value of the treatment.

The three main weeds present in the area were ragweed, lambsquarter and smartweed, all three of which were easily killed as long as they were no more than two inches in height.

At the time of the first spray the temperature was 65°F., the sky was cloudy but no rain fell. The temperature was 89°F. and the sky was clear on the day the second application was made.

Six combinations of rates of application were compared to the hand weeded check. All treatments were replicated four times. The treatments, yields, time and cost required for weeding are shown in Table 1.

Discussion of Results

The treatments were so designed that the total for the two applications amounted to 10, 15, 20, 25 and 40 pounds of potassium cyanate per acre. The rate of application on the first date of spraying for treatments 1, 2, and 4 was five pounds per acre, ten pounds per acre for treatments 3 and 5 and twenty pounds per acre for treatment 6. On the second date of spraying quantities of the weed killer sufficient to bring the total to the desired amounts was applied. All quantities of the chemical were applied at the rate of 60 gallons of water per acre.

The yields shown in Table 1 represent the number of 50# bags of onions per acre harvested. The yield of 394 fifty pound bags per acre for the check or hand weeded plot was significantly less than any treatment. It is evident that the weeds which could not be normally removed depressed the yield on these check plots. In actual practice the grower would abandon any acreage as badly infested with weeds as the untreated areas of this field.

Table 1.

The Effect of Rate of Application of Potassium Cyanate on Yield, Hours Required for and Cost of Hand Weeding of Onions

Treatment	Pounds of Potassium Cyanate applied			Onions 50# bags per acre	Hours/acre required for hand weeding	Cost/acre for hand weeding Labor at 70¢ per hour
	Pounds per acre Total for all treatments	Pounds per acre 1st spray treatment	Pounds per acre 2nd spray treatment			
1	10	5	5	569	268	187.60
2	15	5	10	613	233	163.10
3	20	10	10	667	224	156.80
4	25	5	20	746	149	104.30
5	25	10	15	728	118	82.60
6	40	20	20	597	126	88.20
7	0	0	0	394	583	408.10
				L.S.D. 171	L.S.D. 67.6	

There is a general trend, although not statistically significant, which indicates that the best treatment may be at the rate of 25 pounds per acre for the season. The yields increased as the total application increased but again

decreased when 40 pounds of potassium cyanate was applied.

The effect of the material as shown by yield data is further borne out by total hours per acre required for weeding, the cost of the hand weeding in dollars and the weeds per square foot after each treatment. The hours per acre and cost per acre for hand weeding decreased as the total rate of application increased except in the case of the 40 pound application which was similar to the 25 pound treatment. All treatments required significantly fewer hours and, therefore, cost less for hand weeding than the check areas which were entirely hand weeded. It is admitted that this difference may have been accentuated by the poor weather for hand weeding, but it shows further that by means of this material, the grower might save a crop which he would otherwise abandon.

The effect of the treatments as indicated by weed counts is shown by the data in Tables 2 and 3.

Table 2.

Number of Weeds Per Square Foot after First Spraying with Potassium Cyanate

Treatment*	Number of Weeds Per Square Foot after First Treatment
Check	103
5# per acre	39
10# per acre	26
20# per acre	10

*All plots receiving the designated rate were used in calculating the number of weeds per square foot i.e., plots 1, 2 and 4 were treated with five pounds per acre.

Table 3.

Number of Weeds Per Square Foot on June 12 after Second Spraying with Potassium Cyanate

Treatment	Number of Weeds Per Square Foot after Second Treatment
Check	134
10# per acre	18
15# per acre	11
20# per acre	8
25# per acre	8
40# per acre	7

These data show the effectiveness of the spray under the conditions of the experiment. Not enough plots were involved to determine questions relative to the maximum or minimum number of sprays which may profitably be used.

Conclusions

1. Potassium cyanate in a spray at the rate of 60 gallons per acre was effective as a weed killer in onions on muck soil in northern Indiana.
2. As much as 20 pounds per acre of the chemical may be used if weeds are a serious menace. Ten pounds for the first application may be safely recommended.
3. The first application can be applied while the onions are in the cotyledon stage.
4. Onions with three true leaves are not seriously injured by a second application.

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EXPERIMENTS ON THE CONTROL OF WEEDS IN ONIONS GROWN ON PEAT SOIL BY THE USE OF CHEMICALS

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In the growing of onions, much time and energy is spent in the eradication of weeds. It has become a general practice to grow onions on the same ground year after year. With the proper cultivation and timely hand weeding

each year the ground becomes less weedy than the year before. The main purpose is then to control the weeds. Since the depression years of the 30's the cost of labor has increased. Wages have risen to the point where it becomes necessary to produce more as well as to market at an increased price. How then can the grower of a crop like onions eliminate at least part of the "stoop labor" associated with this crop? The possible answer is to use selective chemicals or sprays which will kill the weeds but will not materially affect the crop. With the success that has followed the use of oils in the growing of carrots, it seems logical to at least think that the same sort of procedure may be effective in the growing of onions. However, oils used to eradicate weeds in carrots kill the onion plants.

The use of selective sprays is not a new thing. In the early part of the century there was considerable interest in using iron sulfate to control mustard in grain fields and dandelions in lawns. In France and in Norway, sulfuric acid was used to control weeds in grain fields. It became known too that dilute sulfuric acid could be used to eliminate weeds in onions. In many sections of the United States and in England the use of sulfuric acid in the weeding of onions is an established practice. Grigsby of Michigan had advocated the use of a two percent solution of sulfuric acid applied about 3 weeks after emergence and a second spray about two weeks afterwards, at a rate of 100 gallons per acre. Certain precautions are necessary. The acid should be poured into the water and not water into the acid. Zinc or galvanized containers cannot be used. The person doing the spraying must wear rubber or woolen clothing as cotton and sulfuric acid are not compatible. The spraying equipment must be made of material that is not affected by acid, the container will need to be made of lead. Such equipment has been difficult to obtain.

In 1933, Sinox (Sodium dinitro-orthocresylate) was developed as a herbicide in France and introduced into the United States in 1937. It is an acid dye made from the by-products of the distillation of coal. It is non-corrosive and relatively non-poisonous as compared with arsenicals. An acid salt such as ammonium sulfate enhances its effectiveness. Sinox has been used to eradicate annual weeds in transplanted onions. It has been used to control weeds in seed onions but one must be careful not to use it when the onion plant is too small. In New South Wales the recommendation for Sinox (called Dinoc) is that the onion plant should be at least 4 to 5 inches high showing at least the third leaf. A 3/4% solution of Dinoc with ammonium sulfate was used with some success.

The two materials, then, sulfuric acid and Sinox, had certain limitations. An attempt was then made to see whether it would not be possible to employ some other compound more effectively. Attention was focused upon sodium pentachlorophenate (Santobrite, Dowicide G). Santobrite had been used as an industrial preservative and fungicide and extensively employed in the manufacture of insulating board, paper adhesives, leather, etc. for the control of slime and algae. Hance of Hawaii had used it to enhance the effectiveness of sodium chlorate. It had also been used as a potato vine killer.

In 1944 in cooperation with Dr. R. A. Kaberg of the Monsanto Chemical Company, St. Louis, Missouri the first attempt at seeing whether Santobrite could not be used to kill annual weeds in onions was made. The trials were conducted on the peat ground of the Crystal Lake Experimental Farm operated

by the Iowa Agricultural Experiment Station. In the spring of that year the ground had been flooded through heavy downpours of rain. The replanted onions were small and at the time the weeds grew faster than the onions. On the night before the sprayings were made a heavy rain had beaten many of the young onion plants into the ground. Nevertheless, sprayings, using one and two percent Santobrite solutions, were made. It was found that the Santobrite had killed the onions along with the annual weeds. In another area where the rain had not been sufficient to wash out the onions and where they were bigger, further tests were made with one and two percent solutions. Here most of the annual weeds were killed without any apparent injury to the onions. From the limited experimental work in 1944 it was evident that sodium pentachlorophenate looked promising as a selective herbicide for onions.

In 1945, with the cooperation of Professor E. L. Barger of the Agricultural Engineering section who constructed a small power sprayer which was attached to the rear of a Ford tractor, a number of solutions were tested. A short time previous 2,4-D (dichlorophenoxyacetic acid) compounds were reported as being the solution of all our weed problems. It was found that none of the 2,4-D formulations were satisfactory, as the onion plant was as susceptible to injury as the associated weeds. The smartweed for example did not grow any more but curled and twisted in all sorts of shapes. The basal node swelled to two to three times the normal size. In fact weeding, in areas where the onions had not been killed became more difficult than where no spraying had been made. It was found later that these onions that survived were markedly stunted. It was evident that the spraying of young onion plants with 2,4-D to control weeds was not feasible.

In 1946, again in cooperation with Professor Barger, spraying operations were confined to Sinox, Dow Selective, sulfuric acid and Santobrite. One section of the field was given over to the standard weeding and cultivating. The onions of the Yellow Globe-Brigham Strain were planted on April 16 on peat soil at Crystal Lake, Iowa, with the aid of a Planter Jr. planter. Each four row (14 inches) strip was twenty inches apart. The wheels of a Ford tractor 72 inch tread traveled the same path when spraying or cultivation was done. The first spraying was done on June 12. At the time the onions were 4-5 inches and the third leaf had appeared. The solutions used, Sinox, and Dow Selective, 3 pints per 100 gallons of water, sulfuric acid 2 percent and Santobrite 1/2 percent, were applied with the aid of a power spraying equipment consisting of 5 Hudson Perfection sprayers attached to a frame of a Ford tractor. By means of a centrifugal pump attached to the power take-off, a pressure of 30 pounds was maintained throughout. The rate was 120 gallons per acre. The weeds which were up were killed but many weeds came up afterwards. On June 29 the second spraying was made. It was noticed that the Santobrite was particularly effective in killing the smartweed. The lambsquarter was more resistant but was stunted in both top and root development so that the subsequent weeding became much easier than in the control, or the bed treated with sulfuric acid. There was only the one weeding, which was done after the second spray application. The harvested yields of marketable onions per acre are recorded below.

Table 1 - Yield of onions per acre sprayed with herbicides.

Santobrite	8727	pounds
Sinox	6960	"
Dow Selective	6240	"
Sulfuric acid 2 percent	7440	"
Control - hand weeded	11124	"

The data show that the onions grown in the regular way produced the greatest amount of material. Of the beds chemically treated the Santobrite gave the best results followed by Sinox and Dow Selective. However, when one considers that the chemically treated onions were only weeded once, and that after the second spraying, the loss would be economically accounted for by the increased cost of the weeding operations.

In 1947 the various post-emergence treatments were repeated at Crystal Lake. Heavy rains during the early part of July caused the ground to become flooded and thus destroyed the experiments.

The work on the control of weeds in onions was continued in 1948 at Crystal Lake, Iowa and involved both post-emergence and pre-emergence treatments. The onions of the Yellow Globe variety, strain Brigham were planted in beds of four rows, 14 inches apart, 180 feet long on April 20-21. Each bed was separated from the next by 20 inches. A Ford tractor with a tread of 72 inches was able to follow the same path each time. All spraying operations in 1948 with the exception of the sulfuric acid was done with a Bean power sprayer, having a 72 inch tread to its wheel base. The pressure was adjusted so that 50 pounds was present. The sulfuric acid was applied with a lead-lined knapsack sprayer. Naturally the best time to make weed eradication sprayings is when the weeds are small. Complete coverage, which is necessary, is more easily obtained. At the same time less material is used. The onion plant then should be as far advanced in its growth as possible and have the third leaf. It is then clear that onions should be planted as early in the spring as the ground will permit. The effect of one spraying of Sinox, sulfuric acid 2-1/2 percent, Aerocyanate and Dow Selective on the yields, along with weed counts on the first weeding, are given in Table 2.

Table 2. Yields of onions given one spray application along with the number of weeds, present per square yard. Planted April 20, 1948, treated June 2, 1948.

Chemical Spray	Number of weeds per sq. yard	Yield in pounds 180' x 6' bed
Sulfuric acid - 2 1/2 percent	203	1140
Santobrite - 2 1/2 lbs. per 100 gallons water	170	1050
Santobrite - 4 lbs. per 100 gallons water	250	833
Sinox - 3 pts. per 100 gallons water	106	721
Sinox dust - 2 percent	192	533
Aerocyanate - 1 percent	70	866
Dow Selective	181	689
Control - (Hand Weeded)	68	680

From the data presented it appears as if it should be possible to materially reduce the weed stand in growing onions by the use of several chemical spray compounds. This reduction in the weed stand is of course particularly significant when the first weeding operation takes place. Sulfuric acid 2-1/2 percent volume heads the list followed by Santobrite with a slightly lower weed count

and decrease in yield. The 1/2 percent Santobrite was apparently too severe at the time of the first spraying. The weed count was greater than in the more dilute Santobrite solution and the yield was less. The aerocyanate showed the lowest weed count, the yield was greater than the control but lower than the sulfuric acid or the Santobrite - 2-1/2 pounds per 100 gallons. Aerocyanate, a selective weed killer, is given the property of eradicating most weeds troublesome to the onion grower without damage to the crop. According to the manufacturer, pigweed and lambsquarter are readily killed. Aerocyanate is effective in killing purslane; annual grasses are also killed. On contact with the soil, Aerocyanate breaks down to form ammonia and akaline carbonates leaving no harmful residues.

In the 1946 spray tests the onions were given a second spray application. In the case of Santobrite the concentration was greater than what was used the first time. In the next series of tests two applications were made. The data are given below in Table 3.

Table 3. Yields of onions given two spray applications where onions were planted April 20, 1948. Sprayed June 2 and June 10, 1948.

Chemical Spray	Number of weeds per sq. yard	Yields in pounds per bed 180' x 6'
Sulfuric acid - 2-1/2 percent (2)	79	855
Santobrite 2-1/2 - 5 lbs. per 100 gals. water	155	715
Santobrite - 4-8 lbs. per 100 gallons water	177	694
Sinox - 3 pts. per 100 gals. (2)	---	482
Sinox dust (2)	---	286
Dow Selective (2) 3 pts. per 100 gallons	---	439
Control	68	632

In the series given the two spray applications before weeding the sulfuric acid showed up better than the others. The 8 pounds of Santobrite cut the yield slightly, but even so was ahead of the Sinox, Dow Selective, and control. In all probability the second spray followed the first too closely as all showed a drop in yield. The two controls were about the same. It becomes a matter of timing to get the greatest resistance to the chemical spray on the part of the onion plant and the least resistance to the spray on the part of the weeds.

Dr. Clinton E. Peterson of the Truck Crops Section performed some experiments on the chemical weeding of onions at Clear Lake, Iowa, this past year. The onion seed bed was prepared on April 6 and the variety Iowa Yellow Globe 44 was planted on April 13. The first selective sprays were applied on May 21 when the onions were in the two-leaf stage 3-4 inches long. At that time the weeds were about one-half inch high. The rate of application was 100 gallons per acre and applied with a knapsack sprayer. The plots were 18 feet long and had four rows of onions. The stand and yields were the means of 5 plots. The two middle rows of a four row bed were harvested for yields. The weed counts were made one week after the application of the spray. The data is given in Table 4.

Table 4. Stand, yields and weed counts of onions sprayed with different chemical compounds. (Peterson)

Chemical Treatments	Stand	Yield - bu. per acre	Total number of weeds
Check (Control) hand weeded	359	754	1349
Santobrite 2#/A 5/25, 2#/A 6/4	345	713	---
Santobrite 2#/A 5/25, 4#/A 6/4	338	659	---
Aerocyanate 5#/A 5/21,5#A 5/28,10# 6/4	348	728	781
" 5#/A 5/21,10#/A 5/28,15#/A 6/4	369	714	770
" 5#/A 5/21,10#/A 5/28,20#/A 6/4	317	705	698
" 5#/A 5/21,20#/A 6/4	394	726	848
" 10#/A 5/21,10#/A 5/28,10#/A 6/4	345	768	342
" 10#/A 5/21,15#/A 5/28,15#/A 6/4	340	767	388
" 20#/A 5/21,15#/A 6/4	379	738	434
" 20#/A 5/21,20#/A 6/4	347	781	178
Nacl-200#/A 5/21, 5/28 - Cyanate 30#/A 6/4, 6/25	377	765	723
Least significant difference P-.05	47	74	

In an examination of the data the Santobrite and the Aerocyanate did not reduce the stand considering the least significant difference as 74; there was no significant difference in the yield except in the two and four pound Santobrite treatments. The weed counts for the Santobrite were not taken as the treatments were delayed in order that the onions would have two true leaves. No control was accomplished except on the very small pigweeds and smartweeds.

The cyanate treatment at the five-pound rate gave some control of pigweed and smartweed; ten pounds was more effective in the control of pigweed and smartweed and 20 pounds was still more effective for these two weeds. However lambsquarter was not eliminated except through hand weeding. The growth of the above-ground parts was stunted. The roots were also stunted making the subsequent hand weeding operations easier.

In the use of Santobrite and cyanate the respective materials must be used when the weeds are small.

At the Des Moines meeting of the North Central States Weed Control Conference in 1946, there were reports of the possibility that 2,4-D could be added to the soil shortly after the seed was planted. In addition to killing broad-leaf annuals, grasses like foxtail were prevented from growing.

In the spring of 1947, Dr. Clinton Peterson of the Truck Crops Section of the Iowa Agricultural Experiment Station, treated soil with the ammonium salt of 2,4-D at time of planting the onion seed at Crystal Lake, Iowa, at rates of one, two and four pounds. He found no reduction in stand even at the two and four pound applications. Floods destroyed the experiment early in July so no data could be obtained.

In 1948, he repeated the experiments and obtained the results given in the following table where the figures are means of six plots of four rows, ten feet long.

Table 5. The effect of 2,4-D (Ammonium salt) pre-emergence treatments of onions on stand, yield and weed control. (Peterson)

Treatment	Stand	Yield bu. /A	Total Weeds
Check (no treatment)	145	749	56
1/2 lb. per acre 2,4-D	156	769	46
1 lb. per acre 2,4-D	165	781	45
2 lb. per acre 2,4-D	162	848	34
4 lb. per acre 2,4-D	155	830	21

The results indicate that there is a possibility that weeds in onions may be materially reduced through pre-emergence treatments with 2,4-D. Before 2,4-D can be generally recommended further tests must be made. The success in using pre-emergence 2,4-D treatments for onions, will be dependent upon moisture content of soil, rainfall, and other environmental factors just as in corn. Pre-emergence treatments made in 1947 on corn were generally satisfactory while in 1948, due to dry weather, the general results were poor.

In another series of pre-emergence tests on onions Dr. Peterson tested fuel oil and 2,4-D (ammonium salt) at time of planting April 13, at Clear Lake, Iowa. The data are recorded in the following table.

Table 6. The effect of pre-emergence treatments on onions planted April 13 at Clear Lake, Iowa - two rows - 18 feet long. (Peterson)

Treatment	Stand	Yield bu./A	Total Weeds
Check (hand weeded)	359	754	1349
Fuel oil 4/26	322	727	361
2,4-D - 1#/A planting 4/13	347	703	343
2,4-D - 2#/A planting 4/13	336	790	136
2,4-D- 4#/A planting 4/13	256	641	135
2,4-D - 8#/A planting 4/13	165	491	104
Stoddard Solvent - 75 gals./A	331	730	326
Cyanamid dust - 100# - 4/26	347	782	684
Cyanamid dust - 200# - 4/26	317	757	341

The results gotten at Clear Lake are much in line with those gotten at Crystal Lake. The pre-emergence treatment with fuel oil reduced the weed population, had little effect on the stand and the yield. 2,4-D treatments above two pounds (and equivalent) are not justified.

In another series of pre-emergence onion experiments made at Crystal Lake, Iowa, in 1948, the seed (Yellow Globe - Brigham strain) was planted on April 20, in beds 180 feet long. Five different compounds were tested, Stoddard solvent (Stanasol) Sodium pentachlorophenol one percent, pentachlorophenol in Diesel oil, amine salt of 2,4-D (Tufor 40) two pounds per acre, ester formulation of 2,4-D (Tufor E) two pounds per acre. The treatments were made on April 30, four to five days before the onion seedlings had broken through the ground. The weed counts were made on June 3. The data are recorded in Table 7.

Table 7. Effect of five different chemical compounds upon the yield of onions and control of weeds when used as pre-emergence treatments.

Treatment	Yields - pounds per bed 180 x 6	Weeds per sq.yd.
1. Stoddard solvent (Stanasol)	1234	375
2. Sodium pentachlorophenate 1 percent 100 gallons per acre	1251	233
3. Pentachlorophenol in Diesel oil - spreader 100 gallons per acre	1332	272
4. Amine salt - 2,4-D - 2 lbs.	1313	162
5. Ester - 2,4-D - 2 lbs.	1328	128
6. Control - hand weeded entirely	1301	371

From the data, submitted in Table 7 where there were three replications, none of the solutions produced a significant decrease in yield except the Stoddard solvent. The number of weeds per square yard were about the same. The sodium pentachlorophenol and the pentachlorophenol reduced the stand of weeds. The best results were obtained by using 2,4-D compounds. Of the two the ester formulation gave the highest yield and the lowest weed count. In the case of the ester formulation it was noted that the weed growth was held back for a longer time. When the first hand weeding was done June 3 the weeds were much smaller than those beds given the other pre-emergence treatments, even the amine.

On the basis of the results gotten at Crystal Lake, Iowa, and at Clear Lake, Iowa, the 2,4-D pre-emergence treatments look particularly promising at the two pound per acre rate. Whether the application is made at time of planting or four or five days before the seedling has broken through the ground. If the weeds can be kept down until the onions have attained a considerable size it may be possible to employ certain post-emergence sprays to much better advantage from the standpoint of weed control. The results do not justify any recommendations for a large scale use of 2,4-D on onion seed beds. A combination of unfavorable weather or soil conditions might mean disastrous results. For those who may wish to try 2,4-D, apply it to only a small area at the rate of not more than two pounds per acre.

CHEMICAL WEED CONTROL IN HORTICULTURAL CROPS

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During the 1948 growing season, the study of the use of chemical weed killers in vegetable crop production has been continued by the members of the Horticulture Department. In addition, studies have been initiated relative to the control of weeds in other horticultural crops by Dr. W. P. Judkins, small fruits, and by Dr. L. C. Chadwick, ornamental plants and nursery management.

In this paper today some of the results of these studies will be briefly discussed. The horticulturist is primarily interested in the crop, and since it is increasingly apparent that chemical weed control must fit into a particular pattern for each crop, the results are presented by crops where possible.

2,4-D Studies in the Greenhouse

The use of 2,4-D with many crop plants in an effort to control weeds has developed so rapidly that there has been very little basic study regarding environmental and soil conditions and their influence in the effective use of this material. At the request of the Sherwin-Williams Company, Cleveland, Ohio, and with their financial support, this study was started during the spring of 1948. A general summary of results under appropriate headings are included below.

Soil Type.- Both the sodium salt and the alkyl ester form of 2,4-D demonstrated greater herbicidal properties on the sandy loam than on the silt loam soil. This greater herbicidal action was apparent not only with the grasses and the broad-leaf weeds but also in increased damage to the crop plant. Sweet corn and asparagus were not seriously damaged, as indicated by later growth, with 2,4-D applications on sandy loam. Snap beans, lima beans, onions, and peas were severely retarded with any of the 2,4-D treatments on the sandy loam.

Depth of Planting.- Asparagus, sweet corn, lima and snap beans, and peas were planted at one and two-inch planting depths and onions at one-half and one inch depths. With lima and snap beans, peas and onions, the deeper planted seed revealed less damage than shallow planted seed as indicated by seedling and plant development. With sweet corn and asparagus, there was no significant difference in regard to the depth of planting.

Form and Rate of 2,4-D.- There was no major difference in weed control with the one pound rates (acid equivalent) of the sodium salt or the alkyl ester. The two-pound rate of the sodium salt did not give significantly better weed control than the one pound rates of the sodium salt or the alkyl ester. Crop damage, however, was usually more severe with the two-pound rate as compared with the one pound rate. The two-pound rate of alkyl ester was not included in this study.

Total Volume of Solution Per Acre.- All of the 2,4-D applications were made at the rate of twenty-five gallons total volume (water) per acre. One-half of each flat was sprayed and the other half of the flat served as a check. Very thorough coverage of each half flat was obtained as indicated by weed control. There was no indication of a lateral movement of salt or alkyl ester in the flat and there was a very clean sharp line between the treated and untreated sections of each flat.

Time of Application.- In most cases, treatments applied several days after planting seed produced fewer harmful effects on pea, onion, snap bean and lima beans than treatments applied either immediately after planting or just prior to emergence of the crop seedlings.

With sweet corn and asparagus, the time of treatment did not appear to influence significantly the amount of damage to the seedlings. Treatment at seeding probably resulted in the most damage to sweet corn, but three weeks after application it was not possible to determine differences between any of the series of treatments. Apparently with sweet corn and asparagus, the time of treatment did influence the damage to the crops but the recovery period was much shorter for these crops than for pea, onion, snap and lima beans.

Applications of the 2,4-D from time of seeding up to 6 or 7 days after seeding gave excellent control of grasses as well as broad-leaf weeds. However, it was apparent that the temperature was an important factor in relation to germination of the grass weeds (foxtail and crabgrass). When treatments were delayed and grass seedlings were visible at time of treatments, there was minimum control of grasses. If the temperature was seventy or above (F) and grasses were germinating but with no visible emergence, excellent grass weed control was obtained. Control of broad-leaf weeds was obtained with all application series.

Varieties of Vegetables.- A general evaluation of variety response to applications of 2,4-D pre-emergence treatments.

Onion - less damage to Brigham Yellow Globe than to Sweet Spanish.

Peas - less damage to Alaska than to Thomas Laxton.

Snap bean - less damage to Giant Stringless Green Pod than to Round Pod Kidney Wax.

Lima bean - less damage to Henderson Bush than to Fordhook #242.

Sweet corn - Ioana, most resistant; Marcross, intermediate; and Golden Cross Bantam and Spancross, most susceptible. None of the sweet corn varieties showed serious damage as measured by stand, various height measurements, and fresh weight of tops, in comparison with untreated varieties.

Asparagus - only one variety was used in this test, Mary Washington. Comparison of treated and untreated plants did not show any significant damage to this variety.

Proximity of Susceptible Plants in the Greenhouse to Treated Flats (2,4-D):

All of the flats were treated in a separate room and were kept in this room for twenty-four hours after treatment. After this period they were placed in the greenhouse and the experiment was carried to completion without moving the flats. At the time of bringing each series of flats into the greenhouse, tomato plants in two-and-one-half-inch-pots were placed at various distances from the treated flats. At daily intervals thereafter these tomato plants were carefully checked for any evidence of 2,4-D damage. None of the tomato plants exhibited any symptoms of 2,4-D damage through the eight-week period of study However, when tomato plants were placed in the same room where flats were sprayed with either the sodium salt or the alkyl ester, the damage was readily apparent.

Conclusions.- One pound (acid equivalent) of the sodium salt or alkyl ester of 2,4-D did not materially reduce the development of four varieties of sweet corn and one variety of asparagus during an eight-week period of study following applications of both materials at various times in pre-emergence sprays. One and two-pound rates of the sodium salt and one pound rate of alkyl ester of 2,4-D used in pre-emergence treatments with varieties of snap beans and lima beans, onions, and peas caused sufficient damage to these crops to discourage their general use in field applications. Deeper planting of seed seems advisable with these crops where 2,4-D pre-emergence sprays are to be applied

The effectiveness of 2,4-D varies with the soil type in regard to seed control and crop damage. Better weed control with greater crop damage can be expected with equivalent rates of 2,4-D on the sandy soils. This also indicates that reduced rates of 2,4-D might be suggested for sandy soils as compared with the loams to clay loams.

Field Studies

Asparagus

Pre-emergence applications of 1.0 lb. of the alkyl ester, acid equivalent, per acre, were applied 2 and 13 days after planting the variety Mary Washington in a Miami silt loam. Post-emergence applications of 0.25 lb. of the alkyl ester and 0.50 lb. of sodium salt were made when the asparagus seedlings were 1" high and somewhat protected by the weeds which were 2" high. The pre-emergence treatment 13 days after planting was very effective in controlling weeds for a period of seven weeks. There was no reduction in stand or other visible damage noted with asparagus seedlings following pre-emergence applications. The seedlings in the cultivated checks were only half the size of the treated seedlings after ten weeks. Post-emergence treatment with the alkyl ester caused foliage burn of asparagus seedlings but controlled broadleaf weeds so that cultivation was much easier than with untreated checks. The sodium salt post-emergence treatment while not causing damage to seedlings did not give satisfactory weed control. The damage to asparagus seedlings from post-emergence treatments was slight as indicated by comparison with untreated seedlings 3 to 4 weeks after treatment.

Asparagus Planting (13 years old).- During the 1948 season, 1.0, 2.0, and 3.0 lbs. acid equivalent per acre of the alkyl ester and sodium salt of 2,4-D were applied at various times during the cutting and post cutting period to a 13-year-old planting of Mary Washington asparagus. Retreatment of certain plots with 1.0 and 2.0 lbs. of the alkyl ester of 2,4-D or aromatic oil (15%) 50 gallons per acre alone or in combination with 1 to 5 lbs. of pentachlorophenol were also made during the post-harvest period after discing. The treatment sprays were made when the asparagus was 24" to 30" high and the sprays were directed at base of plant.

One and 2.0 lbs. of the sodium salt and 1 lb. of alkyl ester applied after the first cutting did not give satisfactory weed control for more than three weeks. Retreatment over these plots with 2.0 lbs. alkyl ester four weeks into the cutting season gave excellent weed control, particularly with Canada thistle, through the rest of cutting season. The 3.0 lbs. sodium salt and 2.0 and 3.0 lbs alkyl ester gave fair to good weed control for six weeks when applied after first cutting. None of the 2,4-D treatments resulted in any visible damage to asparagus except where exposed spears were sprayed.

The best weed control in the post-harvest season was obtained where 2.0 lbs alkyl ester was applied and followed immediately with 50 gallons aromatic oil containing 1.0 lb. pentachlorophenol. This treatment completely eliminated weeds for six weeks and as of October 15, there was practically no weed competition. Slight burning at the base of some spears was noted a few days after spraying but this was apparently minor in relation to the development of plants during the season.

Sweet Corn

Yield, Maturity, and Stand Studies.- During the 1948 season Spancross, Marcross, Golden Cross Bantam, and Ionana varieties of sweet corn were planted (Miami silt loam) in a split randomized block arrangement with 32 treatments replicated three times. The alkyl ester and sodium salt at 1.0 and 2.0 lbs., acid equivalent, in 20 gallons total volume of water per acre were applied 2, 4, and 8 days after planting as corn pre-emergence treatments. Post-emergence applications of 0.125, 0.25, and 0.50 lbs. of alkyl ester, and 0.25, 0.50, and 1.0 lbs. of sodium salt, were made when the corn was 2" and 9" high. With the corn 18" high, 0.24, 0.50, 1.0 lbs. of alkyl ester and 0.50., 1.0 lb., and 2.0 lbs. of sodium salt, were applied as post-emergence treatments. Two check or untreated, replicated plots were also included. All plots were hoed and cultivated 49 days after planting, and this was the only cultivation throughout the season. The alkyl ester in all instances gave better weed control than the same rates of the sodium salt. All varieties of sweet corn were visibly damaged when sprayed at 18" height with the higher rates of the alkyl ester. There were no statistically significant differences in stand, maturity, or total yield of any variety of sweet corn as related to any of the 2,4-D treatments.

Irrigation after 2,4-D Treatments.- One pound, acid equivalent, of the alkyl ester and two pounds, acid equivalent, of the sodium salt were applied as pre-emergence treatments at time of planting and at four days after planting on Spancross, Marcross, Golden Cross Bantam, and Ioana varieties of sweet corn. One-half of each of the above plots received one inch of supplemental irrigation, one hour after 2,4-D treatment. The sweet corn was grown to maturity and there was no indication of reduced stand, or other deleterious effect on any of the varieties as a result of the supplemental irrigation following treatment.

Inbreds and Commercial Varieties.- Twenty-eight inbred and commercial varieties were planted and treated with 0.0, 1.0, 2.0, and 4.0 pounds, acid equivalent, of the alkyl ester of 2,4-D in twenty gallons of water per acre, one hour after planting. There was practically no reduction in stand of any of the inbreds or commercial varieties at the one pound rate. At the two-pound rate, the varietal difference was evident with twenty-five varieties and at the four-pound rate, only two of the twenty-eight did not show a marked reduction in stand.

Snap Beans and Lima Beans

During the 1948 season, Giant Stringless Green Pod, Round Pod Kidney Wax, Fordhook 242, and Henderson Bush varieties of beans were planted (Brookston silt loam) in a randomized block with 12 treatments, replicated three times. The alkyl ester and the sodium salt of 2,4-D at 0.5 and 1.0 lbs., acid equivalent, per acre in 20 gallons of water were applied 1 and 6 days after planting. Dow Selective at 5 pints per 100 gallons, Dow General at 2 pints per 100 gallons, and 50 gallons aromatic oil (15%) plus 1.0 lb. PCP were applied 6 days after planting. One check or noncultivated (until July 1), replicated plot was included. All plots were hoed and cultivated July 1 and cultivation was continued as needed throughout the season. Excellent weed control was obtained with all 2,4-D applications and fair to poor weed control with dinitro, and oil sprays. The major weeds included lambsquarters, purslane, galinsoga,

smartweed, foxtail and crabgrass. The 2,4-D treatments caused visible damage to all varieties of beans but did not materially affect the stand. The lima bean varieties were least affected by the 2,4-D applications and Henderson Bush seemed particularly resistant. Round Pod Kidney Wax was damaged more severely than Giant Stringless Green Pod.

Statistically significant reduction in yield occurred following the application of the 0.5 and 1.0 lbs. of alkyl ester and sodium salt six days after planting with both varieties of snap beans. There was no statistically significant reductions in yield of lima beans following any of the 2,4-D dinitro, or fortified oil applications.

Onions

Sweet Spanish, Red Globe, White Globe and Brigham Yellow Globe onion varieties were planted in a Brookston silt loam. The alkyl ester at 1.0 and 0.5 lbs. and the sodium salt at 1.0 and 0.5 lbs., acid equivalent, were applied one day after planting. The alkyl ester at 0.5 lb.; the sodium salt at 1.0 lb.; aromatic oil, 100 gallons per acre; and 3 pints Dow Selective per 100 gallons water per acre were applied eleven days after planting but before emergence of the crop. Sodium pentachlorophenate, 80 pounds per 100 gallons of water and Dow Selective, 3 pints in 100 gallons of water, were applied as post-emergence treatments when the onions were 2" high. Sodium pentachlorophenate at 8.0, 12.0 and 16.0 pounds per 100 gallons of water, and Dow Selective at 3, 5, and 7 pints per 100 gallons of water were applied as a post-emergence treatment when the onions were three to four inches high. The alkyl ester at 0.5 lb. and the aromatic oil at 100 gallons per acre applied as pre-emergence treatment produced excellent weed control for several weeks with practically no damage to onions. The 8.0 lb. sodium pentachlorophenate in 100 gallons water per acre applied when the onions were 2" high gave excellent weed control for three weeks and there was practically no damage to any of the onion varieties. All other 2,4-D treatments caused severe damage to all onion varieties. The other treatments did not give adequate weed control.

Spinach

Virginia Savoy, Long Standing Bloomsdale, and Viroflay varieties of spinach were planted in a Miami silt loam. Pre-emergence treatment of 1.0 lb., acid equivalent, of the alkyl ester and the sodium salt of 2,4-D were applied 3 days after planting, and 100 gallons of aromatic oil (15%) was applied 7 days after planting. Weed control was good with both 2,4-D treatments but poor with the aromatic oil.

All 2,4-D treated plants were less vigorous, smaller, less lateral root development, and a rather thin tap root as compared with untreated plants. One week after treatment, some plants showed evidence of rotting of the tap root. There was likewise an unusual development of lateral roots high up on the tap root and the crown. Some of the 2,4-D treated plants revealed severe twisting of the petioles, particularly with the older leaves. There was a marked delay in the flowering response of spinach that had been treated as compared with the untreated. Vegetative growth of the 2,4-D treated plants continued 2 to 3 weeks after the untreated plants had started to flower.

Strawberries

Tests on Newly Set Plants.- Premier, Scarlet Beauty, and Catskill varieties of strawberries were sprayed with 0.50 and 1.0 lb. of alkyl ester, and 1.0 and 2.0 lb., acid equivalent, sodium salt 30 days after planting. The major weeds were smartweed and assorted grasses.

Sodium salt did not give satisfactory weed control in any dosage used in these tests. Alkyl ester gave partial control at the 1.0 lb. acid application but this was not a satisfactory commercial control of weeds.

All varieties of strawberries used in these tests suffered severe distortion of leaves for a week following the application of 2,4-D. After this period the plants recovered and made growth which appeared comparable to unsprayed plants. The stand of runner plants at the end of September was not significantly different between sprayed and unsprayed plants.

2,4-D as used in these tests did not give satisfactory commercial control of weeds in strawberries. It is doubtful if it was of benefit even as a supplement to the usual methods of control with cultivation equipment and hand hoeing.

Earlier applications and possibly repeated applications would seem to offer the best possibilities for success.

Tests on Bearing Age Plants.- One-year and two-year-old plants of Premier were treated with 0.50 and 1.0 pound of the sodium salt and 0.25 and 0.50 pound of the alkyl ester were applied to replicated (3) plots just past the full bloom stage.

The leaves of the plants were severely distorted for several days following the spray application and then gradually recovered.

Yields of fruit in the 1-year-old planting sprayed with the sodium salt were slightly higher than from unsprayed plots. Yields in the alkyl ester plots were slightly lower than from unsprayed plots. None of the yield differences were statistically significant.

Yields of fruit from all sprayed plots in the 2-year-old planting were slightly below those of unsprayed plots but the differences were not statistically significant.

In most instances it would seem impractical to attempt to control weeds in strawberry plantings by spraying during the blossoming period of the fruiting year. At this time any weeds which are present would be in a relatively advanced stage of growth and difficult to kill. If, however, it could be shown that certain weeds could be controlled by spraying at this season the yields would not appear to be seriously reduced by 2,4-D sprays at the strengths used in these tests and applied when the plants are past the full bloom stage of development.

Control of Herbaceous Weeds in an Elm Planting

Sixty different formulations of 2,4-D; 2,4,5-T; aromatic oils; pentachlorophenol; sodium pentachlorophenate; potassium and sodium thiocyanate, sodium trichloroacetate; various dinitro compounds; and combinations of some of the

above were applied to replicated plots (2) in an elm planting. The plot size was 100 square feet and the predominant plant species in all plots were recorded before treatment. Applications were made in July and observation on effect of sprays on species were made three and ten weeks after treatment. All of the above sprays were applied in two gallonage totals per acre. There was no indication of more effective weed control from increased gallonage (lowest gallonage per acre, 20 gallons). The elms were spaced 10x10 and were 4" to 6" in diameter. The sprays were directed on weed foliage and care was exercised to avoid spray drift to elm foliage above weeds.

There was no apparent damage to any of the elms following treatment through October 26, but observation will be continued into the 1949 season. The most effective spray in this test was two pounds of 2,4,5-T plus 3 pints of Dow General in 50 gallons of water (per acre basis). Excellent weed control was obtained and despite the dinitro contact content in spray the increased damage apparent in later observations indicated considerable 2,4,5-T effectiveness.

2,4-D FOR WEED CONTROL IN ORCHARDS, SHELTER BELTS, AND ORNAMENTAL PLANTINGS

Glenn Viehmeyer, University of Nebraska, North Platte Substation

From the results of the past three years testing of the herbicide 2,4-Dichlorophenoxyacetic acid it appears that this herbicide may have a place in controlling weeds in plantings of decidious and evergreen woody plants. Results to date, indicate that if a reasonable amount of caution is exercised in applying the chemical it can be used without apparent effect on even the more susceptable woody species. The words "apparent effect" are used advisably, since, at this stage of the investigation, there is no information available, regarding possible cumulative effect of repeated applications on fruit and ornamentals.

The experimentation of the past three years, plus results reported by others and numerous field observations has made it rather clear that the formulation of 2,4-D used in weed control in plantings of this type is of prime importance. All evidence points to the fact that the esters of 2,4-D are not safe to use because of their volatility. Many cases of injury to trees and shrubs have been noted. Some of these were the result of using an ester of 2,4-D within the planting, but many were from the use of the formulation for weed control in adjacent areas and were clearly chargable to the volatilized material being carried to the affected plant by air currents.

In a few cases injury was found at considerable distances from the treated area. Apparently degree of injury is in direct proportion to the volume of the herbicide used. As an example; isopropyl ester of 2,4-D at the rate of 1/4 lb. of acid per acre, applied to an area of twelve acres caused severe distortion and minor killing effects to the tips of chinese elm at a distance of four hundred feet from the treated area. In another case 2,4-D response was noted in a tomato field one thousand feet from a sprayed area. In a third case death or distortion to house plants resulted from a few spoonsfull of ester being spilled on a sidewalk fifteen or twenty feet from the window where the plants were growing and similar results were observed on roses growing at least fifty feet from the same source.

In view of these reports of injury, it seems advisable to recommend that the use of esters of 2,4-D within or near plantings of susceptible ornamental or fruit plants be avoided.

The salts of 2,4 D on the other hand are not volatile enough to cause injury to most ornamental or fruit plants and can be used with reasonable safety if care is exercised to prevent the herbicide coming in direct contact with the foliage of the plants in question. No case of injury to plants growing adjacent to areas treated with a salt of 2,4-D has been reported or observed, except those where drift of dust or spray material directly to the affected plant occurred.

In using 2,4-D in the orchard, windbreak, or ornamental planting, it should be considered as a supplement to, not as a substitute for cultivation, and be used only in those places inacessible to cultivating equipment.

The satisfactory use of the herbicide in plantings of this type, is dependent upon the skill and care of the operator. Such skill and care will, to a large extent, determine the success or failure of the operation. The operator must realize that he is dealing with a type of crop that cannot be readily replaced if he makes an error, and that extreme care in his operations is mandatory.

The use of low pressures and coarse sprays is important to minimize danger of drifting spray material. On low plants the use of windboards or shields helps avoid direct contact to the desirable plants in the area being treated. Application should not be attempted during windy weather because of the danger of drifting spray materials.

It should be remembered that the rule that succulent, rapidly growing, plants are more susceptible to 2,4 D than more mature ones is true of woody species as well as herbaceous ones. Trees and shrubs are more easily injured during rapid spring growth than they are later in the season when the season's growth has hardened and ripened.

The time alloted for this report will not allow a classification of woody plant material as to susceptibility to the herbicide. Varieties differ in degree of tolerance, and even wider tolerances are found between species. For those who wish to use 2,4 D in tree or shrub plantings the following observations are given.

SMALL FRUITS:

Raspberries and blackberries: This class of plants is quite tolerant to 2 4 D and little damage occurs even where the herbicide is applied directly to the foliage. An occasional case of canes splitting following 2,4 D application has been observed in Sodus raspberry.

Ribes species:

Most currants and gooseberries appear susceptible. 2,4 D should be used with extreme care to avoid direct contact.

Bush cherries:

Sandcherries, sandcherry hybrids, Nanking, Korean cherries and other low growing Prunus species are susceptible in the rapid growth stage. Use extreme care in application.

Grapes:

Grapes are so susceptible that use of 2,4 D for weed control in vineyards seems inadvisable.

Tree Fruits: Apple, apricot, cherry, peach, plum, etc., are all somewhat susceptible, particularly in rapid growth stage. However, in most cases such trees are headed high enough to make application of the herbicide possible without direct contact with the foliage. With care, contact with trunk and lower branches can be avoided. No evidence of injury has been observed even though limited amounts of spray material have, in a few cases, reached the trunk and lower branches.

WINDBREAK AND ORNAMENTAL TREES AND SHRUBS:

Evergreens: Coniferous evergreens have, as a class, proven to be quite tolerant even to direct applications. Some injury has been observed where application has been to young, tender, new growth.

Deciduous species: Application in established stands has caused no injury. Small deciduous stock should be protected, both foliage and bark, from direct application. Shrubby plants should be protected from direct application to lower branches since such application may result in the loss of these branches and ruin the shrub an an ornamental.

In a summarization of possible uses of 2,4-D in orchards, windbreaks and ornamental plantings one may say that the herbicide apparently has considerable promise as a supplement to cultivation practices, particularly for weed control in places that would otherwise require hand weeding. Certain precautions should be observed. These are:

1. The use of esters of 2,4-D in or near plantings of woody material is dangerous and should not be attempted except in cases where the trees or shrubs are known to be highly tolerant to the herbicide.

2. The skill and care exercised by the person making the application is of utmost importance. Do not become careless.

3. Use low pressures and coarse sprays to minimize danger of drift.

4. Use windboards or shields of some sort to protect low growing shrubs and small woody plants from spray material.

5. Do not attempt application on windy days.

It is stressed that this work is still in the experimental stage and that a considerable period of time must elapse before definite recommendations can be made. An investigation of the possible cumulative effect of repeated applications is needed. It is suggested that future investigations include soil treatment to control both broad-leaved and grassy weeds in the row where cultivation is not possible.

In view of the present limited knowledge, the only recommendation that can be made is--"Take it easy". Remember that you are dealing with a high value crop that cannot be replaced without considerable time and expense. Keep your work with woody plants on an experimental basis until more is learned about long time results.

SOME ASPECTS OF WEED CONTROL IN SMALL FRUITS (PRELIMINARY REPORT)

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Small fruits, especially strawberries and raspberries, require a great amount of labor in the control of noxious weeds. Considerable preliminary research has been done in recent years using various chemicals for weed control. The initial work using 2,4 D to control weeds in strawberries, was reported by Carlson in 1947 (1). Since then, a great deal of work has been done in the field testing susceptibility of strawberry varieties to 2,4 D. At the 1947 annual conference of NCWCC, Viehmeyer (6) reported on "Varietal differences in tolerance to 2,4 D in strawberries." He observed a degree of tolerance among hybrid and commercial varieties. This work confirmed the earlier report by Carlson that 2,4 D could be used to control weeds in strawberries under certain conditions. Otis (5) used one quart of Dinitro-o-sec-butylphenol (Dow General) and 30 gallons of Diesel oil in 100 gallons of water to control annual weeds in strawberries. This formulation burned the foliage of both weeds and strawberry plants, but the latter recovered. Three periods for applications of this material were suggested by Otis, namely; (1) Early spring before growth begins, (2) in summer immediately after harvest, and (3) in fall prior to killing frost.

In 1947 Gilbert (4) used 2,4 D both as pre planting and post planting applications on the Sparkle and Pathfinder varieties. The pre planting application of 2 pounds per acre retarded the growth of grasses and weeds for 6 weeks without any noticeable ill effect to the strawberry plants. Post-planting applications made June 20 and September 20, at 1.5 and 1 pound per acre, respectively, gave good control of the broad leaved weeds without injuring the strawberry plants. Although the data are not completed, Gilbert believes that the Sparkle and Pathfinder strawberries will respond favorably to both pre-planting and post-planting applications of 2,4 D.

Neville et al. (5) used the sodium and ester formulations of 2,4 D at rates ranging from ½ to 2 pounds per acre of the acid on the Catskill, Fairfax and Premier varieties. One month after application these varieties compared favorably to the untreated strawberry plants.

A limited amount of work has been done in the control of annual weeds and grasses in raspberry plantings. Although not reported, 2,4 D has also been tried. The annual weeds are easily controlled at herbicidal concentrations of 2,4 D, but formative effects occur on new shoots of raspberries. By proper timing of applications it is possible that 2,4 D could be used in commercial plantings. Grasses have also been controlled in raspberry plantings by the use of general contact herbicides of the dinitro formulations, but control is not lasting since only surface growth is killed. Recent studies (2) have indicated that TCA (trichloroacetate) possibly could be used in the control of grasses (quack grass and Kentucky blue grass).

Strawberry Varietal Response to 2,4 D

Since 1947 when the preliminary work with 2,4 D to control weeds in strawberries was reported, a great deal of field work has been done testing different formulations, trying different rates per acre, and testing the tolerance of various varieties. In the spring of 1948 six varieties of

strawberries (Gandy, Massey, Premier, Robinson, Sparkle, and Temple) were planted for this purpose.

Two applications of 2,4-D at the rate of one-half pound per acre of acid equivalent were made during the summer as water sprays so as to compare to actual commercial applications. The first application was made two weeks after the plants were set and the second was made five weeks following the first. The field was cultivated one week prior to each application and the soil surface received some of the spray solution. Lambsquarter (Chenopodium album L.), Dandelion (Taraxacum officinale), and Sprurry (Spergula arvensis L.) were destroyed by the treatments.

The differences between varieties, although slight, were noticeable. Observations were based on examinations of the plants at the end of the growing season. Leaves, runners, crowns, and roots of plants from the treated rows were carefully examined and compared to plants from the check rows. The differences between the varieties were small, that is, there was a degree of curling of the leaves and a slight browning of the roots which was attributed to the 2,4-D treatments. The varieties are listed in decreasing degree of tolerance as follows: Robinson, Sparkle, Temple, Premier, Massey and Gandy. By the end of the growing season the production of runners of the treated plants compared favorably to the check plants.

Field Applications of 2,4-D on Strawberries by Commercial Growers.

During the summer of 1948, several growers in Michigan used 2,4-D at low concentrations to control annual weeds in first-year plantings of strawberries. One grower, Thomas Moss of Kent County, sprayed five acres of Robinson and Premier at the rate of one-fourth pint of a 40 per cent amine formulation of 2,4-D per acre. The application was made May 1, or one week after planting. Mr. Moss reports, "After spraying we did not have to hoe the berries until the middle of June saving at least one hoeing. I think that if I had cultivated the berries after each hoeing and had applied 2,4-D, I would have saved two hoeings which cost $45.00 each." No serious injury was reported from any growers using 2,4-D at low concentrations and with a low volume of spray per acre.

From the tests previously mentioned and from information from reliable growers it seems that 2,4-D (at one quarter to one-half pound acid equivalent per acre) can be recommended for use on the first year strawberry bed. The spray should be applied with low volume nozzles (approximately five gallons of the water solution per acre) because of minimum wetting of strawberry plants. High volumes per acre are apt to cause the herbicide to soak or run into the crown, and produce injury to the strawberry plant. Two applications during the season might be advisable depending on the weed problem and the tolerance of the variety grown.

Chickweed in Commercial Strawberry Plantings

Common chickweed (Stellaria media (L.) Cyrill) often becomes a serious problem in commercial plantings of strawberries in some sections of the country. In some cases the growers have had to abandon the second crop,

because the cost of eliminating this weed by hand is prohibitive. Due to its creeping habits it soon spreads over a large planting and becomes a matted mass both in the row and between the row.

In 1947, 2,4-D was tried as a control measure as soon as the chickweed appeared in late September and again in late October, and November. However, the chickweed was resistant to 2,4-D both at the seedling stage and when in full foliage. No satisfactory control was obtained by the use of 2,4-D.

Further testing, including other materials such as the dinitro compounds, IPC and combinations of IPC and 2,4-D, was continued in the fall of 1948. IPC (isopropylphenylcarbamate) was included because it had been observed previously that the common chickweed was killed by it when used on quack grass on lawns. The dinitro compound was used because of the favorable response secured by Otis.

Applications of IPC at the rate of 5, 10 and 15 and 25 pounds per acre were made in September, when the chickweed had emerged, and in October and in November. The IPC was diluted with talc and applied as a dust over the row. One month after the application the chickweed was dead in the rows that received the 10 15 and 25 pound applications, while some was still alive in the rows that received the 5 pound rate. At that time it appeared that the strawberries in the rows that received the 25 pound rate had been injured slightly whereas the rows that were treated at the rate of 5, 10 and 15 pounds per acre were normal.

The applications of the other materials previously mentioned were made later and no data are as yet available.

Weed Problem in Raspberries

The broad-leaved weeds as a rule do not cause too much trouble in raspberries, especially where the hill system of growing is employed. In some locations such grasses as quack grass (Agropyron repens L) and Kentucky blue grass (Poa pratensis L.) become established in the older bed. It is the general opinion that these grasses interfere with spraying and harvesting operations.

Field applications of TCA (3) made in the fall of 1947 and in the spring and summer of 1948 indicate that these grasses can be controlled satisfactorily without injury to the raspberry plants if applied at the proper time. Applications were made November 10, 1948, and April 28 and July 6, 1947, at the rate of 10, 30 and 60 pounds per acre. It was observed that the fall applications controlled the grasses satisfactorily with the least amount of injury to the raspberry plants. The 10 pound application, although reducing the stand, did not control the grasses. Thirty pounds per acre gave better control whereas 60 pounds eliminated these grasses from the row.

The April applications at the same rates per acre compared favorably with the fall applications as far as grass control was concerned but some chlorosis of raspberry foliage was observed during the summer. The buds of the raspberry plants were breaking at the time of the application and the plants were not dormant as they were when the fall application was made.

Considerable foliage injury was obtained from the summer applications although the grasses were controlled at the higher rates.

No appreciable difference in cane length was observed among the various treatments (Table 1). It was noticed that Kentucky blue grass was more resistant to TCA than was quack grass. The fall application proved to be the most successful as compared to the spring and summer applications. This probably was due to the fact that the raspberry canes were dormant and the grasses were still green when the material was applied.

TABLE I - - Comparative lengths of raspberry canes from plots treated with TCA at different times and at different rates per acre, the effect of treatments on leaves of the raspberry plant, and effect on the grasses. Observations made: September 6, 1948.

Date of Application	Pounds Per Acre	Cane length in inches	Leaf Chlorosis	Effect on Grasses	
				Quack grass	June grass
November 10, 1947	10	45.9	None	X	X
	30	44.5	Slight	0	X
	60	46.4	Slight	0	0
	Check	44.3	None	XX	XX
April 28, 1948	10	43.2	Slight	X	X
	30	40.4	Medium	0	X
	60	33.0	Medium	0	0
	Check	42.8	None	XX	XX
July 6, 1948	10	39.0	Slight	X	X
	30	43.6	Medium	0	X
	60	38.8	Serious	0	0
	Check	41.6	None	XX	XX

XX = Matted with grass

X = Reduction in stand of the grass

0 = Complete control of the grass

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Wednesday afternoon, December 8

Leland Hotel Ballroom

SECTION III - NON-TILLABLE LAND

Chairman, L. W. Melander

In his opening remarks, the chairman stressed the increased interest during recent years in the eradication of woody plants and stated that continued research will expedite the solution of some of the problems that now are encountered. He briefly reviewed the importance of alternate hosts in the spread of certain diseases. For example, the eradication of red cedars near apple orchards is essential to control apple rust. Buckthorn (Rhamnus spp.) is the alternate host of crown rust. Gooseberries and currants are the alternate hosts for white-pine blister rust, and their eradication is essential if white pine is to exist in the future and be an important source of lumber. Various species of barberry are alternate hosts for stem rust of wheat, oats, barley, and rye.

At the present time barberries are being eradicated in the 18 states that produce approximately 2 billion bushels of grain a year, and blister-rust control work is being done in 26 states where white pine is an important timber crop.

Both the blister-rust and stem-rust-control projects have tested many chemicals for killing Ribes and Berberis species. In 1923 the Barberry Eradication Project started using common salt for killing barberries, and since that time many hundreds of carloads of this chemical have been used. Kerosene was used where salt was not desirable. In recent years, cut-surface treatment techniques have been worked out whereby ammonium sulfamate and concentrated 2,4-D are used for killing B. vulgaris. Foliage sprays of 2,4-D have also been found effective for killing various species of Ribes and the Western native barberry, B. fendleri.

In conclusion, the chairman pointed out that there are many problems yet to be solved in using chemicals to kill alternate hosts and other undesirable woody shrubs.

The following papers were presented to an audience of over 200 people:

KILLING UNDESIRABLE SHRUBS ON RANGES OF THE SOUTHERN GREAT PLAINS

E. H. McIlvain 1/

(Prepared for presentation to the non-tillable land section of the North Central States Weed Control Conference, Springfield, Illinois, December 8, 9, 10, 1948)

Removal of undesirable shrubs from sandy rangeland of the Southern Great Plains increases production of forage and yields larger returns in the form of beef than any other improvement practice developed at this time. Dense stands of sand sagebrush may produce up to two tons per acre of plant material that is largely wasted as far as beef cattle are concerned. After the brush is eradicated, the high-producing tall grasses, sand bluestem, little bluestem, switchgrass, Indian grass, and sand lovegrass, increase more rapidly than short grasses such as blue grama and sand dropseed. Pastures on the Southern Plains Experimental Range which were mowed in June 1943 and again in June 1944 now present an appearance similar to the tall-grass region of eastern Kansas. Other experimental pastures which were not mowed but have been grazed lightly since 1941, or at a per acre rate less than one-half as heavy as the mowed pastures, continue to look much like the adjacent privately-owned range. Needless to say, returns from mowed pastures have been more than double the lightly grazed pastures and about 80 percent more than those moderately grazed. The increase in forage on these sandy lands after brush removal is phenomenal; so is the advantage in net returns from the treatment.

Since I am completely unfamiliar with the brush problem in permanent pastures east of the range country, I plan to leave enough time for a discussion from the floor on this important problem.

MECHANICAL TREATMENT

Investigations for mechanical control of sand sagebrush and other shrubs have been conducted extensively since 1937. The studies have included (1)

1/ Assistant Range Ecologist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, U.S. Southern Great Plains Field Station, Woodward, Oklahoma.

comparisons of various mowing attachments, (2) detailed date-of-mowing tests with sagebrush, skunkbush, and shinnery oak, (3) comparisons of the mower with other implements, (4) chemical analyses of the root reserves in sagebrush, skunkbush, shinnery oak, and prickly pear cactus at semi-monthly intervals during the growing season and at monthly intervals during the winter, and (5) grazing tests on mowed and nonmowed pastures to determine effect of treatment on grazing capacity, cattle gains, and range forage production.

Ordinary heavy-duty, power, take-off mowers, equipped with snub-nosed guards for heavy brush or rock guards for medium-heavy brush, heavy underserrated sections, and a complete set of hold-down clips, have been effective in cutting most local types of brush when operated in low gear the first year, and in ordinary gear but the opposite direction the second year. Disking, railing, or rolling have been less effective than the mower in cutting surface growth of brush. Brush beaters remove surface growth more completely than the mower but are more difficult to keep in working order.

Sand sagebrush was effectively controlled by mowing in June for two successive years and keeping livestock off the range from June to fall of those years. Chemical analyses conducted through the cooperation of Dr. J. E. Webster of the Oklahoma Agricultural Experiment Station revealed that sagebrush roots contain the least carbohydrates and other food constituents in June, and, therefore, can be controlled most effectively by mechanical treatment at that time, or by chemical treatment earlier. The low point of food reserves in roots of other plants occurred in May for skunkbush, on April 1 and June 1 for pricklypear, and on May 15 for shinnery oak. The root reserve studies have an important bearing on the proper time to control shrubs by spraying with 2,4-D, since all of the shrubs grow actively for a month or so before the roots reach the minimum point of carbohydrate storage.

Although sand sagebrush and many range weeds are effectively controlled by two successive mowings, most other troublesome shrubs are too big and tough to mow successfully, or they produce vigorous root sprouts. Shinnery oak and sand plum are not easily mowed, nor are they controlled satisfactorily when mowed. Skunkbush survives mowing treatments much better than sand sagebrush but not as well as shinnery oak. The most objectionable features of mechanical control are the small acreages that can be treated during the short period when the brush is susceptible, and the excessive wear and breakage of equipment.

CHEMICAL TREATMENT

The use of 2,4-D overcomes both of these important objections - particularly when application is by airplane. Extensive tests of airplane application of 2,4-D were made in May 1947 and repeated on an enlarged and more precise scale in May 1948. Simi-monthly date-of-spraying tests have been made with ground equipment throughout the growing season of both years. These studies were conducted near Woodward, Okla., on over 2,000 acres of rangeland infested with sand sagebrush, skunkbush, shinnery oak, and sand plum.

Equipment and Methods

Airplane:

Before giving specific results of 2,4-D studies at Woodward, and because the program of determining how to kill brush with the new chemicals is still in the adolescent stage, I would like to discuss the technique of making airplane spraying tests. At the same time, I will describe the equipment and

methods developed and used at Woodward during the experimental sprayings in 1947 and 1948.

Uniform application of a known quantity of fluid is of primary importance in making airplane tests. Factors governing this important point are proper equipment, well-designed and marked plots, adequate well-trained personnel, proper mixing of materials, and accurate calibration of the plane. Faulty application of material may completely nullify results.

Because spraying is a relatively new business, many improperly or inadequately equipped planes are engaged in the work. A properly equipped plane has a boom extending nearly the width of the wing, effective nozzles, return-flow agitator, wind-driven pump, pressure gauge, and cut-off valves at the tank and at each nozzle. Some common deficiencies are booms 20 feet or less in width, holes bored in the boom as substitutes for nozzles, gravity-flow output of material, lack of a pressure gauge or other device to warn the pilot when the spray tank is empty, and a cut-off valve only at the supply tank. A cut-off valve at each nozzle facilitates starting and stopping the spray without waste of liquid and possibility of damaging adjacent susceptible crops.

Flights may be made crosswind or parallel with the wind; however, observations at Woodward indicate crosswind flights result in more uniform application of material than either down-wind or up-wind flights, particularly under windy conditions. The highest degree of accuracy is obtained by flying in only one direction, unless the wind is directly perpendicular to the direction of flight. Flying in two directions results in a variation in ground speed and a subsequently uneven deposition of fluid.

It is essential that each plot be several plane flights in width. Spray from an airplane may drift 400 feet or more in winds below 10 miles per hour. Therefore, plots should be wide enough so that drift from the upwind side will not extend past the downwind side. This usually requires a minimum plot width of about 600 feet. The minimum effective length is about one-fourth mile. Greater lengths add little value to the test and increase materials cost. Pre-treatment and post-treatment notes should be taken on the downwind side of the plot, since the calibrated quantity of material is deposited only on this side.

The experimental area should be marked distinctly. Plot boundaries can be delimited by high posts or, when in brush-infested terrain, by removing the brush along the border with a mower or heavy brush cutter, as is done at Woodward. The flagmen, who mark each plane flight, must measure accurately the interval between flights. A minimum of three flagmen per flight is necessary for proper alignment of the plane. Two of these men should operate on the end boundaries of the plot.

The plane must be calibrated to put out the desired quantity of material. This should be done with the material scheduled for use on the plots or with material of equal viscosity. Even when accurately calibrated, nozzle stoppage or other factors may vary the quantity of material applied; hence, it is highly desirable to measure accurately the fluid put into the plane before spraying and that left in the tank afterwards.

The chemicals should be weighed or measured accurately and double checked prior to use, and a competent person should be in charge of putting the chemicals into the plane and measuring the quantity left after spraying. A mobile mixing tank with a mechanical agitator will facilitate the work and is essential when using the less soluble powder forms of the chemicals or when emulsifying water and oil. The chemicals and diluents should be thoroughly mixed and ready to load promptly through a hose at least one and one-half inches in diameter. For efficiency of operation, provisions should be made for rapid mixing and loading of the materials within five miles of the experimental area.

Ground units:

The use of ground spraying machines on sagebrush range presents certain difficulties. Most equipment is not made to stand the rough treatment to which it is subjected in bouncing across the average sage-land pasture. Much breakage can be expected unless special braces are welded to the boom and other similar precautions taken. The operator experiences further difficulty in trying to tell where he has been or where he is going; however, the strips can be marked with flagged stakes moved by a man on horseback. Despite difficulties in using ground sprayers, they have advantages for small areas, or for spraying near crops susceptible to injury from 2,4-D.

Determining percentage injury or kill:

A simple, rapid, statistically-reliable method for determining percentage injury or kill has been developed at Woodward. The method uses the principle of the line transect which is widely used in the range country for measuring vegetation. The percentage kill is determined in the spring following the year sprayings are made. A manual count is made of the number of dead and living sagebrush plants in alternate belt transects approximately 6 feet wide and extending either the entire length of the plot or until a specific number of plants have been counted.

A study of the efficiency of this method was made in June 1948. Each of 4 observers read 2 such transects on several plots extending a half mile in length. The data collected were subjected to an analysis of variance. There was not a significant difference between the readings obtained by any one man on 2 transects within each plot, nor between men on the same plot. A reading of 5.1 percent was necessary for a statistically significant difference between plots at the 5 percent level. The method can also be used to measure injury shortly after the sprayings are made by establishing a few well-defined classes and counting the plants in each class.

Miscellaneous techniques:

During the summer of 1948, studies were made to determine the effect of some liquid herbicides on 2 so-called hard-to-kill plants — prickly pear cactus and yucca. The species used were Opuntia humifusa and Yucca glauca. The products used were the salt, amine, and ester forms of 2,4-D, the ester of 2,4,5-T, and diesel oil alone and with the various chemicals. Pouring and spraying were compared with injection of the fluid with a hypodermic syringe. Ordinary veterinary syringes were used with needles about one- and one-half inches long and with a hole about one thirty-second of an inch in diameter. Injections ranging from 1 to 10 cubic centimeters were made

in the basal, middle and terminal lobes of the cactus and in the base and leaves of yucca.

Conclusions as to final kill cannot be made until the spring of 1949; however, several points are worthy of mention. Pouring of herbicides onto yucca plants shows considerable promise -- particularly for small plants. The whorled and cupped leaves form natural basins. Although spraying low volumes of herbicides on cactus and yucca does not cause any apparent injury, a thorough wetting of the surface with concentrated solutions of all forms of 2,4-D and with 2,4,5-T causes shrinking or wilting, discoloration, and rotting of the top growth. Whether penetration and trans-location is sufficient to kill the roots will not be known until 1949. Amine dissolved in water translocated faster and further than any other product. The salts of 2,4-D were next best, and the esters produced effect only where they were injected. The 2,4,5-T translocated only a little better than the esters of 2,4-D. Translocation was better from the terminal lobes of cactus toward the base of the plant than in the opposite direction. The amount of injury was increased by more material from 1 to 5 cc per injection; more than 5 cc per injection did not increase apparent injury.

Another technique which sounds promising is the so called tip-immersion procedure. I do not know where this practice originated but C. E. Fisher of the Spur, Texas, station told us that he is using the method to good advantage on mesquite. I believe the procedure is to immerse the tip of a branch into a test tube of material, tape the tube on the branch, and note the effect of the herbicide. We have not used this method at Woodward but the principle sounds good. Incidentally, the latest word I have is that a practical sure-fire program for killing mesquite with the organic growth regulators has not been worked out.

Results and Conclusions

Since the main results of our work at Woodward were given here last year, and definite conclusions cannot be made yet about the 1948 work, I will give only a brief summary of results. Commercial formulations of methyl, ethyl, butyl, amyl, and isopropyl esters of 2,4-D were compared at various rates per acre with commercially prepared sodium salts of 2,4-D and with a mixture of the pure acid of 2,4-D in a water solution of sodium carbonate (to be here after referred to as a homemade salt). The homemade salt was formulated to provide a product the cost of which would not be prohibitive for use on low value rangelands. It is made by thoroughly dissolving 0.5 pound of sodium carbonate in 4 gallons of water, adding 1 pound of pure 2,4-D and then emulsifying with one gallon of diesel oil. This is sufficient for one acre. Other factors which have been tested include (1) quantity of solution to be applied, (2) use of diesel oil alone or as an emulsion, (3) use of special penetrants, and (4) width of flight spacings.

In all tests, the esters have affected the sand sagebrush more quickly than have the salts. The amines have occupied an intermediate position. However, final percentage kills from the esters, amines, and salts have been about the same -- or nearly 80 percent -- when one pound per acre is properly applied. At rates less than one pound, the esters have appeared more effective, but definite conclusions as to minimum rates cannot be made until next spring

when final readings are made on the 1948 sprayings. Our tests were not adequate to measure accurately any small difference that may exist between the various ester solutions. The homemade salt solution has been effective when properly applied; however, some erratic results have been obtained. Causes of the lack of uniformity in effect are not definitely known, but may be due to improper mixing of materials, use of hard water, poor growing conditions, variations within the chemical itself, or a combination of these factors.

Semi-monthly spraying made during the growing season of 1947 indicated that sand sagebrush was most susceptible to 2,4-D in the early spring when it was well leafed out and growing rapidly. The month of May appears to be the optimum time for controlling sagebrush in the Woodward area; however, date sprayings made in 1948 indicate the possibility that the plant may be effectively sprayed in April.

Three gallons of an ester solution and 5 of a salt solution represent the minimum required for adequate coverage. Poor results have followed every application of one gallon of solution regardless of the quantity of 2,4-D used. The addition of one gallon of diesel oil per acre increased the effectiveness of both ester and salt solutions in nearly every test made to date. Diesel oil used in place of water has been slightly more effective, but it is doubtful if the results are sufficiently greater to warrant the extra cost when as much as 3 gallons of oil are used.

Flight spacings of 30 and 45 feet have been satisfactory when the width of the boom on the plane was 30 feet. Strips of live plants remained when spacings of 60 and 100 feet were used; therefore, a spacing not more than one and one-half times the width of the boom should be considered maximum.

The tests made during the past 3 years showed conclusively that second-growth sand sagebrush plants are more susceptible to treatment with 2,4-D than nonmowed plants. The regrowth on mowed plants is usually dense, succulent, and fast growing. The percentage kill resulting from one pound per acre of homemade salt was 78 percent on nonmowed range and 99 percent on second-year growth.

Range shrubs other than sand sagebrush which are severely affected by 2,4-D include skunkbush, sand plum, and smooth sumac. Those which so far have not been easily controlled are hackberry, shinnery-oak, wild grape, yucca, and prickly pear cactus. Wild grape appeared very susceptible in 1947. Applications in 1948 of one and one-and-one-quarter pounds of the salt, amine, and ester of 2,4-D caused rapid defoliation, but the leaves reappeared vigorously within six weeks.

Many of the desirable range legumes are not seriously affected by 2,4-D applied at the proper time and rate for killing sand sagebrush. Sand pea (Tephrosia virginiana (L.) Pers.), western indigo (Indigofere leptosepala Nutt.) and partridge pea (Chamaecrista fasciculata (Michx.) Greene) are three important native legumes which seem little affected by the spray.

CLEARING WOODY PLANTS FROM RIGHT OF WAYS

R. H. Beatty[1]

Woody plants are cleared and re-cleared from right of ways for the construction, operation and maintenance of railroads, electric lines, highways, telephone lines, pipe lines and many other industrial developments. Realizing that one could not cover in the time allotted all the problems presented by this subject, I am confining my remarks to mechanical and chemical means of controlling brush on utility right of ways.

On the utility right of ways in this country, thousands of acres of woody plants must be controlled so they will not come in contact with the wires and so the right of ways are accessible for inspection or necessary repairs. In the past, this has been accomplished by hand cutting and then piling and burning the brush.

With the increased cost of labor and rapid expansion of the areas involved, utility companies looked for more efficient and economical means of brush control.

Mechanical control

Heavy mechanical equipment of various designs has been tried. The bulldozer cleared the brush from the right of way, but its removal of soil created an erosion problem. The brush rake partly overcame the erosion problem, but still required the additional labor of burning the brush or removing it to disposal plots.

Blading and discing with large Diesel tractors is successful in clearing brush where the terrain permits operation of mechanical equipment. The blade in front of the tractor lays the brush on the ground and the heavy disc harrows pulled in the rear of the tractor eliminate the necessity for removing or burning the woody plants by chewing up the brush and leaving the right of way looking like a plowed field. These machines keep the right of ways clear of brush for a longer period than does hand cutting. By removing stumps and brush, the blade and disc tractors are particularly effective in preparing a right of way for more economical control measures such as mechanical mowing or chemical spraying.

The use of machinery for right of way work is limited by the ground to be treated. The soil may be too wet, extremely rocky, or the terrain too rough or dangerously steep for its efficient operation, and so the utility companies look forward to the many possibilities offered by chemical spraying.

Chemical Control

Chemical control of brush is not a new development. However, many of the early chemicals used were not adaptable to right of way work because

[1] American Chemical Paint Company.

they constituted a fire hazard, were poisonous to livestock, and seriously interfered with the growth of grasses.

Today, we are using three outstanding chemicals which do not have these disadvantages and should be considered in preparing any chemical control program: Ammate (ammonium sulphamate), 2,4-D (2,4-Dichlorophenoxy acetic acid) and 2,4,5-T (2,4,5-Trichlorophenoxy acetic acid).

I have asked several of the men most active in this field to help me in presenting to you the latest information and data concerning the control of woody plants with these chemicals. I thoroughly appreciate their wholehearted cooperation because only by pooling the thoughts and experience of workers from all parts of the country can we clarify the basic principles involved in brush control.

Ammate

Ammate is effective in killing certain woody plants and may be applied as a liquid or in the dry form. The dosage usually recommended is 1 lb. per gallon of water applied to the foliage of the entire tree or sprouts, arising as regrowth; the concentration required will vary with different plant species (5).

With regard to volume, Elwell (6) has found it necessary to use 250 gallons of spray containing 1 lb. of Ammate per gallon on brush having a density of 18,000 to 20,000 plants per acre and an average height of four feet or under. As density and height increase, a maximum of 600 gallons per acre may be required.

Many trees and resprouts are killed by Ammate. Peevy (11) reported that a 32.5% solution (4 lb. per gallon) of Ammate was effective on sprouts 1 inch or less in diameter. Trees killed include black-jack oak, sweet gum, black gum, elm, ash, cypress, bay, ironwood, willow, pine, and the red, post, pin and water oaks. The effect was slower on hickory, beech, persimmon and white oak, and he suggests a heavier dosage on these species.

Elwell (6), using 1 lb. of Ammate per gallon of water, reports kill on crabapple, elm, hickory, locust, oak, osage orange, redbud, sassafras, sumac, wild grape and willow. Tops have been killed on mesquite and persimmon, but re-sprouts occurred.

Ammate is efficient in destroying stump sprouts (5). If the freshly cut stubs or crown of many woody plants are treated with 3 to 5 lbs. of the dry material per square rod (480 to 800 lbs. per acre) death of the stump and roots will occur.

Experimental progress is being made in reducing the amount of Ammate and water required. Elwell and Cox (6) in preliminary tests (July, 1948) with an Orchardaire air blast sprayer report good control of scrubby oak with 50 gallons of liquid and 100 lbs. of Ammate per acre. This air mist machine required only 1/3 as much Ammate and 1/6 as much water as the hydraulic type machine under comparable conditions. If this machine proves effective upon

further test, it will probably be widely used to control low brush on the right of ways over which machinery can operate.

2,4-D and 2,4,5-T

2,4-D and 2,4,5-T are not new chemicals to this conference; a large percentage of the recognized facts concerning their action on woody plants has been published in the Proceedings. Since 1946, 2,4-D has been known to be effective on several woody species (8). Extensive research has continued in an effort to develop chemicals or combinations of chemicals that will control varieties of woody plants common to right of ways which have been resistant to treatments used so far. The specific effect of 2,4,5-T on members of the genus Rubus and other varieties resistant to 2,4-D and the successful use of a combination of 2,4-D and 2,4,5-T on mixed woody vegetation were reported (3) to this conference last year.

Many workers now agree that a combination of these two chemicals (varying the amount of 2,4,5-T from 25% to 50% of the total acid used) is more effective on a greater variety of woody plants than is either chemical used alone.

From the data collected, there appear to be two general methods used for applying these chemicals to right of ways.

Ashbaugh (2), cooperating with the Dow Chemical Company, has been using ester formulations in high volume water sprays. Best results have been obtained with a mixture of 50% 2,4-D ester and 50% 2,4,5-T ester at a concentration of 3000 p.p.m., applying a minimum of 100 gallons per acre. In the spraying operation, he uses a Pecan type nozzle at 250 lbs. pressure.

The other method, used by Kauffman (10) cooperating with the American Chemical Paint Company, involves the application of 2,4-D acid plus 2,4,5-T acid in Diesel oil (at a concentration of 4% total acid) at a rate of 9 to 15 gallons per acre on low brush not over 48" high. This applies 3 to 5 lbs. of total acid per acre. The special knapsack sprayer used to apply these oil sprays is operated at a spraying pressure of 12 to 15 lbs., with low volume nozzles on a four-foot wand carried at the side of the operator. This method is particularly useful in terrain where the mechanical sprayers cannot operate. An experimental low volume unit mounted on a tractor or truck and applying 25 to 40 gallons of solution per acre with varying amounts of oil in a combination of 2,4-D acid plus 2,4,5-T acid shows promise.

Susceptibility of woody plants

In planning the intelligent use of these chemicals for right of way spraying, it is highly important to consider the susceptibility or resistance of the plants to be treated.

Asbaugh (2), using the treatment described, has reported kills on aspen, birch, Rubus spp., box elder, catalpa, dogwood, elm, hickory, horse chestnut, locust, some maples, tuliptree, crabapple, tree of heaven, oak, osage orange, pine, poison ivy, poplar, sassafras, spice bush, sumac, sycamore, wild cherry, wild grape, willow, virginia creeper, honeysuckle, elderberry, walnut and

butternut. He reports ash and basswood as being resistant.

Kauffman (10), Zahnley (13) and Garmhausen (7), working with the 2,4-D and 2,4,5-T in oil spray, report approximately the same species as being susceptible. Kauffman (10) also reports chestnut and sweet gum as susceptible, and finds ash, red maple, persimmon and scrub oak as the most resistant plants. Zahnley (13) identifies the species of susceptible oak as pin, white and scarlet, and lists Osage orange as resistant to the 2,4-D oil spray.

It is evident from the above reports that several of the plants formerly considered resistant to 2,4-D are now being controlled by the combination sprays in water and Diesel oil.

The question of spray drift or volatility should be considered in working with esters on any right of way.

Ashbaugh (2) and other workers using the esters in water at high pressures report some injury to nearby crops, but on the whole have experienced a relatively small amount of damage as compared with the large areas covered.

Kauffman (10) and Zahnley (13), working with the low volume Diesel oil and ester combination, report damage to nearby crops and ornamentals. Epinastic effects have been noted on cotton plants a mile from the point of application of esters in oil in Georgia.

I will not try to determine whether such damage was caused by volatility or spray drift. However, Allen (1) in working with these oil sprays has developed a formulation containing 2,4-D acid plus 2,4,5-T acid and co-solvents that has proven relatively non-volatile in tests and in applications made to 3,000 acres of right of way. Extensive volatility studies are now in progress with these compounds and the cellosolve esters which emulsify in water.

Stump treatment

Another method of chemical control which is of practical importance in controlling right of way brush is the stump treatment. Barrons and Coulter (3) report that a solution of 1% to 2% of 2,4-D ester applied as a stump treatment to species susceptible to 2,4-D has given excellent results. The use of 1% 2,4,5-T ester and 1% 2,4-D ester is suggested for use on species known to be resistant to 2,4-D, such as Osage orange and the genus Rubus. Although there are factors responsible for erratic results, they feel that total regrowth on treated areas may be reduced as much as 75% when such a solution is applied thoroughly to the sides and cut surface of low cut stumps at any time thruout the year. Melander (14) found that European barberry was resistant to cut surface treatments of 2,4-D on field trials.

Kauffman (10), working with a 4% 2,4-D acid and 2,4,5-T acid combination in Diesel oil, reports excellent kill from this treatment applied during December of 1947 to large stumps of most species, including red maple, which is highly resistant to foliage sprays.

Zahnley (13) observed excellent results using the 2,4-D and 2,4,5-T com-

bination in oil if the trees were cut before the leaves fell.

Thimann and Torrey (12), investigating the application of herbicides to the cut stumps of Aroma or Marabu (Dichrostachys nutans) report that a 20% aqueous emulsion of 2,4-D ester applied twice was the most effective in repressing new shoot growth. Higher or lower concentrations of 2,4-D, the ester of 2,4,5-T, and concentrated sodium arsenite solutions were all less effective.

Any discussion of stump treatment would not be complete without mentioning the basal treatment applied to uncut woody plants now being used experimentally by many workers.

Kauffman (10) applied a 4% solution of 2,4-D acid plus 2,4,5-T acid in Diesel oil to resprouted scrub oak about 36" high during the dormant period (December, 1947). It was applied to one group as an overtop spray covering most of the plant, and to the other group as a basal spray covering the sprouts from the ground line to a height of 2 or 3 feet. Resprouting occurred on 25% of the plants given the overtop spray, but by the following summer no sprouting was evident on the basal treated plants.

As a follow-up spray on right of ways this year, basal treatments using Diesel oil, 2,4-D and 2,4,5-T combination have been applied by the single nozzle knapsack to sprouts arising from regrowth and small trees 3 to 4 inches in diameter. Excellent top kill has been noted on ash, red maple and other resistant varieties, showing a longitudinal splitting of the trunk at the point of application, vigorous callus growth and enlarging of the lenticels. Whether or not we are getting penetration into the root system will be determined by spring observations.

Future investigations

All these chemicals are promising but there are many unsolved problems. It is true that there have been conflicting reports on the resprouting of susceptible varieties. This may be due to the concentration of material used, local climatic conditions, etc., but one factor which should be carefully considered in evaluating these chemicals on small plots is the interconnected root systems with plants arising some distance away.

More basic information is needed on whether 2,4-D or 2,4,5-T are inactivated by certain resistant woody plants, or whether there are other factors which explain why these chemicals do not translocate into the root system.

So that we can time our sprays more effectively, experimental data should be obtained on the time in their life cycle when the resistant species show the lowest amount of starch content in their root systems, as it has been clearly determined (12) that 2,4-D sprays reduce the starch content of certain plants.

New chemicals, combinations of chemicals, and better penetrants should be tested on the resistant species. The information contained in the recently published work of Hitchcock and Zimmerman (9) on the activation of 2,4-D

by various adjuvants should be evaluated experimentally on woody plants.

Summary

In summarizing the data presented, a right of way having tall brush should be prepared for chemical treatment by cutting or mechanically treating the brush and then spraying the cut stubble with Ammate or the 2,4-D plus 2,4,5-T combination in oil. After new growth starts in the spring, regrowth should be sprayed by either the high volume or low volume method as the terrain will determine. Follow-up sprays should be used to control the growth as local conditions indicate.

It has been estimated that at least 25,000 acres of right of ways were chemically treated this past summer. When the results of this work are properly evaluated and combined with results of the experimental work now in process, we will have a more definite plan to offer for the control of woody plants.

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CONTROL OF UNDESIRABLE SHRUBS AND TREES IN A REFORESTATION PROGRAM

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Probably more than 10,000,000 acres in the Lake States Region alone are in need of reforestation. A large proportion of this land is covered with a stand of shrubs or undesirable trees making it difficult to establish a stand of desirable trees by reforestation or by natural methods. The problem of establishing stands of timber upon these extensive brush areas is recognized as one of major importance.

The brush and undesirable tree problem is not confined to this region but is found in almost all forest areas. In the southern Appalachian region a shrub understory of rhododendron and mountain laurel makes it difficult to establish desirable tree species. Scrub oak in the southern pine region and manzanita and ceonothus brush in the western pine region are a few of the more important problem species in other regions.

In the Lake States region the key brush species in the areas needing reforestation are probably hazel (Corylus cornuta and C. Americana), alder (Alnus incana and A. Crispa), willow (Salix sp), pincherry (Prunus pensylvanica), chokecherry (Prunus virginiana), mountain maple (Acer spicatum), striped maple (Acer pennsylvanica), dogwood (Cornus sp), Sweet fern (Comptonia asplenifolia), service berry (Amalanchier sp.), hawthorne (Crateagus sp.) and some species of Viburnum and Vaccinium. The relative importance of these species will vary with the site and location but Hazel brush is the outstanding species from the forester's viewpoint. Several tree species, particularly aspen (Populus tremuloides) and paper birch (Betula papyrifera) are often associated with the brush and must be treated with it.

The size and density of this woody vegetation will vary with site conditions and species but if the stand is predominately hazel the height will usually be between 3 and 9 feet and the density will be over 50% of full stocking. Full stocking may involve over 30,000 stems per acre. The size and density of the brush cover therefore constitutes a serious difficulty in any control program. It is difficult to penetrate with spray equipment and its size may make actual spraying very arduous.

Brush control for reforestation purposes involves some considerations which are peculiar to this type of work. First and foremost is the matter of costs. The profits to be made from reforestation lie of course in the difference between costs and returns. In the growing of timber, however, there is one distinctive feature, namely, the long period over which the costs or investment must be carried before returns are realized. In this region this period will range from 40 to 80 years. All of the costs incident to the establishment of the plantation must be carried at compound interest rates over the entire period of the rotation. It is plainly evident, therefore, that it is mandatory that establishment costs be kept to a minimum in order that the returns from the plantation will liquidate the initial investment and maintainence costs as well as leaving a margin for profit. It is only during the last few years that the margin of profit has been large enough to attract any private capital. It is not large enough to permit the carrying of heavy charges for brush control.

Mention has been made of the size and density of the brush species. With the usually brush stands a large area of leaf surface is involved and foliage sprays require a large volume of liquid often difficult to transport. The usual stands of hazel on the lighter soils will probably usually require around 50 gallons of spray solution per acre, on heavier soils and larger species as much as 100 to 125 gallons of solution is often necessary. To further complicate the problem these reforestation areas are often difficult to traverse with any kind of vehicle. Logs, trees, rocks, hills, swamps and other obstacles often make mechanical vehicles short of a bulldozer tractor unsuitable. Some sand plain areas are of course much more suitable for the use of equipment but such areas usually do not have such an acute brush problem.

Unlike some other fields of woody plant control a reforestation program does not require nor desire a complete and permanent eradication of the brush species. It is merely necessary to prevent the brush species from overtopping the planted trees for the first few years after planting. In from 5 to 15 years the plantation will usually have made sufficient height growth to make it impossible for the brush species to overtop the plantation and interfere with further growth and development. In fact, from this point on the brush species are probably desirable both as a source of game food and for their influence on soil conditions.

The chemical control of the brush species offers some very intriguing possibilities and several workers in forestry have been doing research in this field. To the best of the author's knowledge no extensive application of chemical control methods for reforestation purposes have as yet been conducted in this region. Experimental work has been conducted at several points, however, and the results should point the way to such an application in the near future.

Almost all of the problem species being considered sprout freely, and cutting, therefore, does not usually constitute control. Likewise, the killing of the top with a chemical accomplishes no more than cutting it. Shrubs can only be killed by destroying the tissues that give rise to the sprouts. Thus in estimating the value of a chemical for the control of shrubs, one must give primary consideration to the extent of re-growth.

Foliage sprays have been used the most, and with many species have been successful. The 2,4-D salts in water solution of 1000 p.p.m. gave a satisfactory kill on some of the more susceptible species such as hazel and alder but some

inconsistent results have been obtained also. Most workers now favor use of the esters of 2,4-D for foliage sprays. The different esters in solutions of 1000 to 1500 p.p.m. in water have given consistently good results on the species that have proven susceptible. The more important susceptible species are hazel, alder, and willow. Some of the more important species that have been found to be more or less resistent are the maples, hawthorne, dogwood and aspen.

The table below summarizes in brief form the author's experience with the use of 2,4-D foliage sprays on several woody shrub and tree species.

Table I

Species	Formulation	Reaction
Alder (Alnus incana)	esters, 1000 - 1500 ppm	I - II
Aspen (Populus tremuloides)	esters, 1000 - 1250 ppm	III
Aspen, big tooth (Populus grandidentata)	esters, 1250 - 1500 ppm	II
Balsam poplar (Populus Tacamahaca)	esters, 1000 - 1500 ppm	I - II
Chokecherry (Prunus virginiana)	esters, 1000 - 1500 ppm	III
Dogwood (Cornus alternifolia)	esters, 1000 ppm	IV
Dogwood (Cornus Stolenifera)	esters, 1000 ppm	III
Hawthorne (Crateagus sp.)	esters, 1000 - 1500 ppm	II - III
Hazel (Corylus cornuta)	esters, 1000 - 2000 ppm	I
Juneberry (Amelanchier sp.)	esters, 1000 - 1250 ppm	III
Mt. Maple (Acer Spicatum)	esters, 1000 - 1500 ppm	IV
Pincherry (Prunus pensylvanica)	esters, 1000 - 1500 ppm	II
Red Maple (Acer rubrum)	esters, 1000 - 15000 ppm	IV
Willow (Salix sp.)	esters, 1250 - 1500 ppm	I
Withe-rod (Viburnum cassinoides)	esters, 1250 - 1500 ppm	III
Elder berry (Sambucus canadensis)	esters, 3000 ppm	II
Blueberry (Vaccinim pennsylvanicum)	esters, 1000 ppm	III

All treatments made during the mid-season period July 1 to August 15. (1945-48).

Reaction types I, Hypersensitive - II, sensitive - III, semi-tolerant - IV, tolerant.

All formulations are in water.

Water has been used as the carrier for these foliage sprays since it has been found necessary to apply quite a large volume to obtain satisfactory coverage. As mentioned above the volume of water needed will vary with the stand density and size of the brush. Much work needs to be done on the development of mechanical equipment for the application of foliage sprays. The use of knapsack sprayers will probably continue to be the most practical in many areas. Even so it appears that the cost will be comparable to that of mechanical control.

The use of 2,4,5-T as a foliage spray has not been investigated thoroughly as yet. The author has obtained good results in preliminary trials on alder, aspen, and service berry at concentrations of 1000 p.p.m. in water. It was not effective on red oak at this concentration. Zehngraff and Von Bargen (12) obtained results on hazel equivalent to that obtained with the Isopropyl ester of 2,4-D. In work elsewhere it has proven effective on several species which are resistant to 2,4-D, notably Rubus.

Ammonium sulphamate has been used as a foliage spray with varying results. It has been most successful on hazel but on other species it has usually resulted in vigorous re-sprouting, Day (4). However, it is more expensive than 2,4-D and the results have not been as outstanding as those obtained with 2,4-D.

The use of the contact sprays in brush control has not been very successful. The large quantities required have made it expensive and in almost all cases a heavy growth of sprouts has followed the treatment.

The work with the newer chemicals such as TCA has not progressed to a point where any results can be reported.

Cut stump sprays are not usually applicable in reforestation work. Their application is more in that field of forest management which is concerned with the elimination of undesirable components of the stand. However, since such treatments might be used in some reforestation work they will be briefly discussed.

A cut stump spray involves wetting the top and above ground portions of the stump with a concentrated oil solution of 2,4-D or 2,4,5-T. Concentrations of 4000 p.p.m. to 8000 p.p.m. of a 2,4-D ester in fuel oil have been the usual treatment. At the Dunbar Forest Experiment Station it has been found that even as resistant a species as red maple fails to re-sprout after a treatment of 4000 p.p.m. of the isopropyl ester of 2,4-D in fuel oil applied in April to stumps cut during the winter. Recent work has also indicated that it may be possible to decrease the concentration to 2000 p.p.m. and still get good results if a large enough volume of the spray material is used. It appears that certain species which are very resistant to 2,4-D foliage sprays are susceptible to this form of treatment. Barrons and Coulter (1) have also reported that a mixture of 2,4-D and 2,4,5-T is more effective on certain resistant species. They recommend that 1% Esteron 44 (2,4-D) and 1% Esteron 245 (2,4,5-T) be used in 98% fuel oil for the most resistant species. This formulation would have a concentration of 8000 p.p.m. of 2,4-D and 2,4,5-T combined.

Stem sprays refer to the treatment of the stem or trunk only of larger shrubs or small trees. It may also refer to the treatment of smaller shrubs in the dormant condition without foliage. The author has obtained only negative results from spraying the stems of larger shrubs and trees with 2,4-D

solutions. Higher concentrations might prove effective but it appears doubtful that this method of attack is feasible. However, very satisfactory results were obtained when dormant hazel and choke cherry shrubs were sprayed in early April with a solution of 4000 p.p.m. of the isopropyl ester of 2,4-D in fuel oil. The shrubs were from 3 to 6 feet tall and the entire above ground portion was sprayed. The plants did not leaf out and failed to resprout.

The use of the very toxic dinitro phenol (DNOSBP) as a stem spray on aspen has resulted in the death of those below about 3 inches in diameter, Day (5). It is also effective on a few other species such as pincherry and mountain maple which have a smooth thin bark. This treatment should be made during the growing season, however. A formulation of .05 pound of the toxicant per gallon of kerosene was used.

The injection method of killing trees and large shrubs requires the punching or boring of slanting holes in the trunk and the placing of the solution in these holes. This is probably most advantageously done with the tree poisoning axe devised by workers at the Southern Forest Experiment Station. The use of sodium arsenite as a poison for trees has been a recognized practice for a number of years and has proven very effective, Pessin (8), Cope and Spaeth (3). The application of sodium arsenite presents many difficulties with shrubs. The poison should be placed beneath the bark and this can be done efficiently only on the larger shrubs which will permit the use of tools devised for this work. Arsenite is also a deadly poison and its use is dangerous both to the worker and to domestic and wild animals in the area.

The use of ammonium sulphamate (Ammate) by this method has been recommended in the South. The dry powder is used and it is placed in axe cuts or holes cut in the bark around the entire trunk. This has proven effective on many hardwood tree species. The use of this substance in a like manner on red maple stumps did not prevent their resprouting, however.

Of the mechanical methods, cutting is of course the simplest, but the cutting of shrubs which sprout readily cannot be a satisfactory method of control and, therefore, cutting experiments have been more concerned with the rate of growth and density following cutting than with mortality. Cutting in the winter or spring resulted in the most rapid growth and the densest stand, Day (6). The least height growth and the thinnest stands were obtained when the cutting was done in July or early August. Stoeckler (10) obtained comparable results with aspen.

Heavy equipment offers a more efficient means of mechanically controlling shrubs. Machinery capable of doing a satisfactory job has been developed and it is to be expected that new and improved machinery for this purpose will be developed as the problem receives greater attention. When brush control is needed to allow the establishment of a conifer plantation, the equipment used to prepare the area will usually consist of a crawler-type tractor and heavy planting plow or disk-type plow.

The planting plow throws soil up on both sides of the furrow and thus prepares a strip about 5 feet wide, free of brush and other vegetative competition. The length of time that seedlings planted in such furrows will be free from brush competition depends, primarily, upon soil and moisture conditions. On

the lighter, drier soils, brush competition usually will not interfere with the growth of the conifers until they have overtopped the brush. The heavier soils, occupied by red and white pine, will usually permit the brush species to make such growth that the conifers will be unable to overtop them without some form of artificial aid. On these soils in brushy areas the use of heavy planting plows, therefore, cannot be said effectively to control the brush.

The disk-type plow consists of a four-bladed disk of heavy construction and weighing 1400 pounds or over. This plow is faster and simpler to operate and does not become clogged with brush or sod. Experience with the disk-type plow throughout the region indicates that it offers the best mechanical means that has yet been devised for subduing brush.

The use of the disk-type plow does not result in the deep and undesirable furrows produced by the planting plow. Thus, the conifer is planted at ground level and in the top soil, enriched by incorporated humus. This equipment can be used to prepare a seed bed for natural regeneration or for planting. It effects brush control at the same time as preparing the seed bed.

The amount of actual brush destruction that can be accomplished with this equipment is rather amazing. The area is usually covered twice, at right angles, and results in the brush and small trees up to one and two inches in diameter being literally cut up and incorporated in the soil. This is especially so in areas of light soil where disking is particularly effective. A standard of seventy percent exposure of mineral soil has been set up and can be attained on light soils with a single, two way, treatment.

On heavier soils it is more difficult to secure a good kill by disking and better results have been obtained by disking during one summer and then waiting until the next summer to re-disk before planting. Another variation is to disk in the spring before the leaves appear, when visibility is good, followed by additional disking in the summer. July and early August have been found to be the best time to disk from the standpoint of killing the shrub species.

An area prepared with this equipment presents very good conditions for planting or for the securing of natural reproduction of desirable species. Growth of planted trees has been found to exceed that of those planted in furrows by fifty percent, Stoeckler (11). In addition, they have the advantage of being planted at ground level rather than at eight to ten inches below it.

Experience on the Chippewa National Forest in Minnesota with disking indicates that it reduces greatly and sometimes eliminates the need for plantation release. It also has given good results when used to secure natural reproduction, especially of jack pine, and these stands have been able to overcome brush competition.

The latest information from the Chippewa National Forest where this type of equipment has been used most extensively is that a 6 bladed disc is proving superior to the 4. This is pulled by a 40 h.p. crawler tractor. Rudolph (9) states that the cost of a cross discing job will be less than 10% more than a furrowing job. It is also possible to disc areas which are unsuitable for

furrowing. Probably on most planting sites either treatment can be done for less than $10.00 per acre.

The author believes that combination treatments will in time prove to be the most effective. Disking can be done in the areas best suited for it and chemical control methods can be used in the other parts of the area. Chemical control can be very flexible and sprays could readily be used to kill those shrubs that had survived disking, as well as for those in rocky areas that could not be disked.

Burning must also be considered as a means of controlling undesirable species. The use of fire is just beginning to be understood and only in certain sections of the country has it been used successfully. Chapman (2) has described the use of fire as a means of controlling the inferior hardwoods associated with stands of loblolly pine in the southern states. The usefulness of fire as a tool in the management of the southern pines seems to be established. In the northern states the situation is much different. In the first place controlled burning has been in disfavor for fear that its use even on an experimental basis might prejudice the forest fire prevention campaigns. It appears that conditions in this region are not as suitable as elsewhere for the use of fire for controlling the inferior species. The use of fire is of course fraught with certain dangers, especially that of becoming uncontrollable. The effect of fire may also induce more suckering and sprouting and have an opposite result than the one desired.

The control of the brush species by silvicultural measures is accomplished mainly by shading and the establishment of young stands under conditions enabling them to out-grow and over-top the shrubs. A dense, young stand of even the more intolerant species will shade out and eliminate the shrubs for practical purposes and if these stands are reproduced by proper cutting methods before they have opened up with maturity, the shrubs can be kept out indefinitely. Since the shrub species are mostly heavy seeded and invade slowly, a young stand of pine or other desirable species can be established and will be able to over-top the brush species if they do not have the advantage of sprouting from established roots. These statements are particularly true of light soils; the heavier soils tend to favor the brush species.

Silvicultural control has its limitations but should be thoroughly understood and utilized to the fullest. Proper control of cutting can prevent the shrubs from invading stands where they are now absent. Silvicultural measures can also help to eliminate shrubs from young stands and keep them out. The most difficult problem is the establishment of timber stands in areas now dominated by the shrubs. If these areas are given artificial treatment either chemical or mechanical, it should then be possible in most cases to maintain this control by silvicultural methods.

It is a readily apparent that only a beginning has been made in the investigation of all the possibilities of controlling woody shrubs for reforestation work. It is suggested that the most urgent experimental needs at present are the following: (1) More research projects of a comprehensive nature (such as that of Zehngraff and Von Bargen). (2) Cost determinations on larger scale operations. (3) A more complete list of species with their reactions to the different formulations. (4) More experimental work on the possibilities of combining mechanical and chemical methods. (5) More experimental work with the possibilities of controlled burning for brush control.

The brush problem is becoming a greater handicap to reforestation every year and the complete success of our reforestation work is primarily dependent upon the finding of cheap and effective methods of controlling this brush. Considerable progress has been made to date with both mechanical and chemical methods. Discing and plowing have been the best mechanical methods although the search still continues for cheaper methods. Few large scale tests of chemical control have been made yet but the indications are that this offers real possibilities both to lower costs and to increase the effectiveness of control. The results to date on the treatment of hazel with 2,4-D have been outstanding.

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Wednesday Evening, December 8

Abraham Lincoln Hotel Ballroom

SECTION I - INVESTIGATIONS ON WEED CONTROL METHODS IN SUGAR BEETS, POTATOES, SOYBEANS, PEAS, AND SIMILAR CROPS.

Chairman, E. A. Helgeson

PRE-EMERGENCE WEED CONTROL IN SUGAR BEETS

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Pre-emergence weed control is the elimination of weeds by treatment before the crop plants emerge. Without doubt, the most effective period for weed control is before weeds grow beyond the seedling stage. Most crop plants are the weakest, less able to withstand competition during their germination and emergence period than at any other time during their life. Competition from weeds may affect the crop plant in many ways. They may cause shading which may reduce sunlight to the extent that the young seedling is unable to manufacture its own organic foods. The crop plant thus becomes weak and may die of starvation and, if not, may become more susceptible to the ravages of disease and insects. Weeds exhaust oxygen from the soil which in turn changes the biotic relationships resulting for one thing in an increase of fungi that may become parasitic. In weed infested fields, damping off often becomes serious because of the more favorable conditions for such fungi. Crop stands, therefore, are frequently impaired when heavy populations of weeds are present. Good seed and good stands are the first essentials in profitable crop production. Too few growers realize the losses that are incurred by inferior crop stands. One of the important factors affecting stands is weeds and their elimination.

The standard practice of controlling weeds during this early period of the crop plant is proper seed bed preparation. This involves the careful fitting of the soil before planting the crop. By two or more such fittings previous to seeding one or more batches of weeds may be destroyed. If land is kept relatively free of weeds from year to year, then proper seed bed preparation, followed by precautionary cultural practices, results in good weed control most years for some crops. The reason such practices cannot be universally effective is because of the interference of the weather. There are seasons when very little pre-fitting of the seed bed can be accomplished. The soil remains wet and cold and it is impossible to get the weed seeds to germinate. The crop is planted, the weed seeds have the same chance of emerging as the crop plant, and the cultural method of controlling weeds has failed. The degree of failure is regulated by soil types, pattern of farming, crops grown, and the effect of weather on each of these. It must be emphasized that in order to have a weed problem, the weed seeds must be present. Hence, a farmer may greatly reduce his weed problem by careful farming, not allowing weeds to produce seed, and keeping a constant vigilance against them.

The weed problem is usually more serious in special agricultural crops. In this list can be included sugar beets, many of the special vegetable crops,

and others. Sugar beets have always been classed as a hand labor crop. A large proportion of this special labor is required for weeding or is necessary because of weeds. With the shortage and high cost of labor, the growing of this crop is rapidly becoming less profitable and competition from other crops requiring less labor is gradually forcing the beet industry out of the Ohio Farm program.

To conquer these obstacles, three problems had to be solved: (1) the production of single germ segments for seed, (2) the designing of machinery that can be used to block and thin the beets, and (3) control measures for weeds. The seed problem has been thoroughly investigated and considerable progress made.

Beet seed formerly in a ball containing from one to several germs is now cut up (sheared) so that mostly a single seeded segment may be planted. New types of drills have been designed to distribute the seed evenly spaced in the row. For example, if 95 to 100% viable seed are spaced 1½ to 2 inches in a row and the weather conditions are favorable, a stand of single beet seedlings may be obtained that can be mechanically blocked. If there were no weeds present no hand labor would be required for the crop. Carrying the 'if' further, if the spacing could be 3 to 6 inches apart and there were no weed present, neither the mechanical blocking or hand labor would be necessary.

The mechanical blocking phase has also received extensive study and suitable machinery has been developed. One of the machines that has been adapted for blocking beets is the Dixie cotton chopper. This is a two-wheel outfit that has a revolving knife that cuts out desired sections of the row as it is pulled lengthwise of the row. This machine has been used quite widely in the West but is not so adaptable under the eastern beet growing conditions. Another machine, a beet cultivator, has been redesigned by A. C. Joost of the Great Lakes Sugar Co. and blocks beets by being pulled at right angle to the rows. The cultivator contains a knife 8 inches long faced with a disc colter. The distance between each colter-knife set is 4 inches, hence leaving a 4-inch block. The knife and the block may be varied, giving 2,3, or 4-inch blocks. When beet stands are below 40 percent a shorter knife may be used, hence more frequent blocks. The cross cultivator blocker is mounted on a Ford-Ferguson lift. This machine blocks the width of 4 rows and is very economical in time and cost.

The third problem--weed control--is the one remaining obstacle to be overcome. Weeds in the early portion of the sugar beet growing season reduces stands by competition and by increasing disease. A weedy stand not only renders the young seedling more susceptible to damping-off and other root diseases, but also creates a physical condition more favorable for the fungi causing the disease. It has been determined that the quicker a beet seedling can emerge the less like it is to succumb from disease. Likewise, the quicker a young seedling can get air through cultivation, the less likely it is to die from disease. The latter cannot be accomplished if weeds are abundant.

Much study has been given to the problems of growing sugar beets during the past few years. Most of the problems leading up to mechanization have been solved. There remained one problem, the elimination of weeds, which seemed unsolvable. If a weed stands adjacent to a sugar beet seedling, there is only one thing to do and that is to reach down and pull it out. This is

hand labor. The problem had to be solved by not allowing that weed to get there in the first place.

Since the weeds adjacent to the beets required hand labor to remove them, a project was set up to study methods of destroying germinating weed seed in the beet seed bed. The primary objective set forth in this project was to work out a method for pre-emergence weed control in sugar beets. Perhaps it should be stated that it involved a combination of two methods, one by cultural practices, the other by chemical weed killers. At any rate, in practice the two methods of pre-emergence weed killing must be operated together. The cultural method of controlling weeds will be discussed in the descriptions of plot preparation and finally along with the plan of mechanization.

Since the growing of beets depended upon the development of a method for controlling weeds at the seedling stage, it was planned to test as many chemicals under as many conditions as time and labor permitted. Several of the major chemical companies were asked to submit not only promising chemicals, but ideas on how to use them. After assembling all such information, a general plan of procedure was formulated. It involved the testing of every promising chemical submitted and under most conditions that permitted normal beet growing. Three definite timing periods of planting beets were arranged, namely early, medium, and late. In this way it was possible to study the control of different weed populations as the season progressed. The reason that pre-emergence weed killing by chemicals has not been more generally practiced is because of injury to the seedling beet or whatever crop used. This injury did not always occur. Crafts[1] points out that certain moisture conditions govern the safety of the soluble type of weed killers. (Examples are sodium pentachlorophenate and the salts of the dinitro-phenols) This type of material as well as many others were studied.

Other phases of the project included a study of the stands of beets as affected by the various chemical treatments. This involved the percentage of germination, the vigor of the emerged seedling, the incidence of disease and subsequent growth of the plant. Another important phase of this investigation was the determination of the effect of delayed chemical treatment after planting on the effectiveness of the weed control treatment and effect on the subsequent stand of beets. These procedures will be described in more detail in the body of the report. In all of this work, pre-fitting of the soil before planting was considered to be essential to pre-emergent weed control by the use of chemicals. However, delayed planting after fitting is not going to be a desirable practice for growers in most of Ohio's beet territory. The standard recommendation for this region is to sow beets early (late April-early May) and at that time of year frequent rains with slow drying might cause serious delay in planting if the planting did not immediately follow the seed bed preparation. For this reason, other timings of application of the chemical treatment were studied.

The primary factor governing the successful use of the mechanical method of thinning beets is based on the premise that weeds be absent. In fact, if

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[1]Crafts, A. S. Chemical Weed Treatment in Corn. Agric. Chemicals 3: 25. 1948.

weeds did not have to be considered many new usable methods of starting the beets would become available. Consequently, a study was made of this phase in which special drills were used to plant the beets and mechanical thinning to block the beets.

The overall objective of this project was to develop a procedure from plowing and fitting to a blocked and thinned field of beets.

Location and Description of Soil

The experiment was located on the Ralph Watson farm at Old Fort, Ohio. This farm was well adapted for the weed control work because of the type of soil, the weed population, and above all the thorough cooperation and assistance from the owner. In previous years, the more common and troublesome weeds were plentiful. The soil is a dark, semi-heavy clay, not Brookston, but containing considerable sand and humus. It is very productive, containing ample humus and not low in inorganic fertilizer elements. It is a type of soil amenable to treatment. The growth of plants in such soil, with various treatments, shows variations promptly and readily.

The field had been in alfalfa during the two previous seasons and had not been in beets for four or more years. Beets following two years of alfalfa may succumb to black root. Phosphoric acid content is lowered considerably by alfalfa and an attempt was made to correct this by a liberal application (300 lbs.) of 3-18-9 fertilizer. An advantage was obtained by this situation in that it permitted a study of the relationship of treatment to disease incidence. The fertilizer used in all except the first planting contained Arasan (20 lbs. in 1 ton of fertilizer).

Plot Arrangement

The entire experiment was divided into three general phases of operation: (1) The study of 4 formulations of materials believed most promising with three timings and three concentrations; (2) the test of special weed killing chemicals; and (3) the mechanical phase.

Preparation of the Soil and Planting

The plots were spring plowed. A medium heavy sod of alfalfa was plowed down. In general, the fitting was done by standard equipment and in a fashion generally recommended for beets. Certain extra operations were used to level plots or to make a more suitable seed bed. These will be discussed later as they affected the planting procedure.

The three types of drills used were Superior, Milton, and John Deere. The Superior drill was used only in a portion of the early seeded plots that were intended for the mechanically blocked series. While this drill has been the one generally used in the beet growing section, it was not entirely suitable for the major portion of this work. Its feeding mechanism is of the flute type and definite spacings of seed in the row cannot be obtained. It was important in this type of experiment to have a definite spacing of the segmented seed. The drill that seemed to have the best possibilities for the purpose was the Milton single seeder manufactured by the Harbison-Paine, Inc., Loveland, Colorado. While this drill was reputed to be in successful and wide-spread

use in the western sugar beet districts it had a few serious faults when applied to this work. First, the fertilizer attachment was unsatisfactory because of inadequate and uncertain fertilizer placement. To aid in the control of black root, it is necessary to place the fertilizer with or very near the seed. (Young[2].) The seed sowing mechanism of the Milton drill is propelled by float wheels. The drill was mounted on a Ford-Ferguson lift and the entire drill for the four rows was rather rigid. Whenever there was an appreciable unevenness in the seed bed, the float wheels would not turn continuously, hence the seed was sown irregularly, and drill rows passing over such depressions as a middle furrow would not plant at all. This type of procedure caused serious variation in beet stands. Regardless of these handicaps, the drill spaced the seed segments singly and at even spacings when operating properly, a performance that was greatly to be preferred for this work. The faults listed above have now been corrected to meet our conditions.

The first series of plots were drilled at 2-inch spacing in 22-inch rows. Later, 1½-inch spacings were used. Special segmented seed prepared by Mr. A. C. Joost of the Great Lakes Sugar Co., Fremont, Ohio, was used throughout the test. This seed was graded over 9/64 in. and through 10/64 screen and was about 80% single germ segments. The germination was over 90%. The plot size in every case was 7.3 feet by 59.4 feet and contained 4 rows of sugar beets spaced 22 inches apart. The stands of beets obtained in each case are given in the tables. The variations attributed to drilling, or conditions at drilling time, are also discussed along with the results on weed control.

Method of Spray Treatment

In order to minimize differences in treating procedure as much as possible, all the materials, with the exception noted below, were applied in the same manner. A total of fifty gallons per acre of spray mixture was applied using a hand operated pressure knapsack sprayer. The sprayers were equipped with two Spraying Systems Co., No. 8004 "Teejet", nozzles, twenty-two inches apart. The nozzels were held in an approximate vertical position twenty inches from the ground. A pressure of thirty pounds per square inch was maintained in the spray system, and the rate of walking with the sprayer was regulated to give a dosage of fifty gallons per acre. After a little practice it was possible to spray quite uniformly both in coverage and rate of walking. With the nozzle arrangement a slight overlapping occurred at the edges of the spray patterns but this came in the middle of the rows and had very little effect on the spray results.

The exception to the use of fifty gallons per acre of spray mixture were two concentrate applications. These were applied in the same manner as the diluted sprays except that two "Teejet" No. 8001 nozzles were used and the walking rate had to be increased to approximately four and one-half miles per hour to apply 5 gallons per acre.

Materials Used

The materials used for the timing tests were: (1) aromatic oil, (2) 10% by weight pentachlorophenol in the same aromatic oil, and (3) 5% by weight

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[2]Young, H. C. Fertilizer in Relation to the Incidence of Black Root. Am. Soc. Sugar Beet Tech., Eastern Sec. Proc. 3: 23-29. 1943.

2,4-dinitro secondary butyl phenol in the aromatic oil. An emulsifier was added to each to permit their emulsification in water for application. It is generally understood that aromatic oils differ tremendously in their composition. These differences are exhibited by their safety to foliage of crop plants, as well as to their killing factor on weeds. Because of this, it was thought advisable to have all formulations made with one aromatic oil. The Shell Oil Company kindly consented to make all the formulations used with a uniform aromatic oil and emulsifier. A list of the special materials used is as follows:

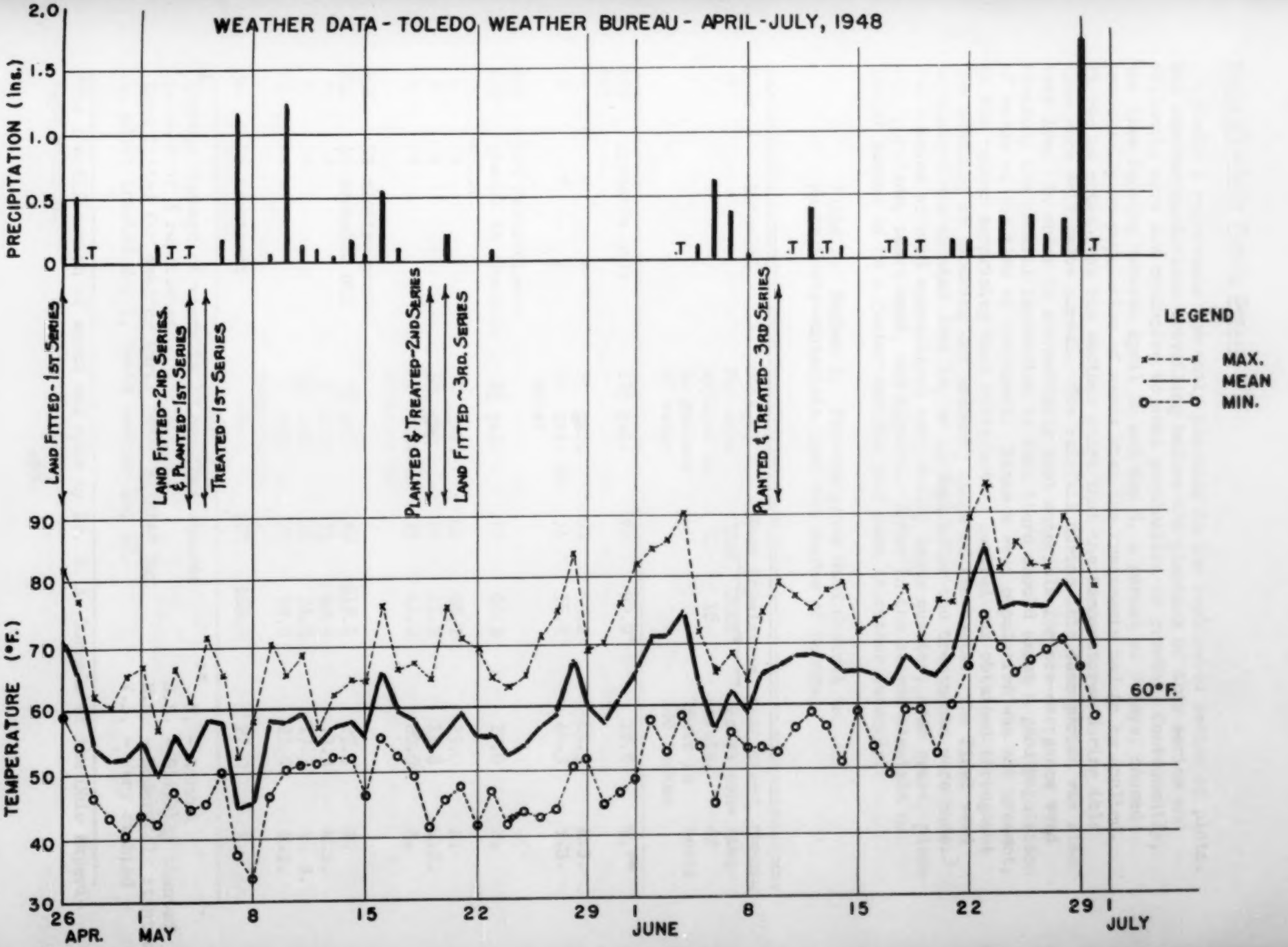
1. Dow Selective. Ammonium salt of dinitro ortho secondary butyl phenol. 1 lb. per 1 gal.
2. H 814 - 50% wettable powder sodium salt to TCA.
3. Nix - Sodium isopropyl zanthate.
4. Pec - in aromatic oil.
5. MACC - mixed allyl chlorophenyl carbonate.
6. MACC 20%, aromatic oil 80%.
7. Sulfasan 50% (Xanthogen disulfide) - aromatic oil 50%.
8. Santobrite, formulation of sodium pentachlorophenate.
9. Tetrachlorophenol - 1 lb. in 1 gal. aromatic oil.
10. 2,4-D ester - formulated as Weed-No-More. 2,4-D ester was used at the rate of ½ lb., 1 lb., and 4 lbs. per acre. Application was made April 28. Beets were planted on a portion of each series at weekly intervals for 4 weeks. No beets came up in any of the plots, hence the experiment was discontinued.
11. IPC - Isopropyl-phenyl-carbamate, 50% wettable.
12. Dowicide G - formulation of sodium pentachlorophenate.

A detailed summary of material used, dosages, weed counts, beet stand counts, and condition of beets are given in the various tables.

The weather during the progress of this experiment was not particularly favorable for weed growth. A weather chart as recorded at Toledo is given in Figure 1. During April an above average rainfall occurred. The temperatures, however, were well below normal. Much of the land for these plots was plowed and fitted during the last week in April. Fairly heavy rains fell during the early part of May, but the temperatures were again below normal until around the 25th. From the 10th of May until the end of June the rainfall was far below normal. This type of weather conditions was not conducive to weed growth and the weed population remained scanty throughout the first planting series and into the second timing. A heavy population of weeds developed during the latter period of the test. The weather factor will be included in the discussion of results obtained from each series.

(Follow as Table 1)

In this type of experiment, all factors, such as soil condition, temperatures, and in general the influence of all phases of weather on seed germination, must be considered and evaluated. Many such details were tabulated during the course of the experiment and can only appear in the discussions and conclusions and amplified by photographs.


WEATHER DATA - TOLEDO WEATHER BUREAU - APRIL-JULY, 1948
PRECIPITATION (Ins.)
2.0
1.5
1.0
0.5
0
.T
LAND FITTED - 1ST SERIES
LAND FITTED - 2ND SERIES & PLANTED - 1ST SERIES
TREATED - 1ST SERIES
PLANTED & TREATED - 2ND SERIES
LAND FITTED - 3RD. SERIES
PLANTED & TREATED - 3RD SERIES
LEGEND
MAX.
MEAN
MIN.
TEMPERATURE (°F.)
90
80
70
60
50
40
30
60°F.
26
APR.
1
MAY
8
15
22
29
1
JUNE
8
15
22
29
1
JULY

Early-Planting Timing Series

Table 1 represents the early planting in the replicated series of plots. The weather conditions prevailing before the planting of this series and following were not conducive to weed germination or growth. Consequently, the time lapsing between April 26 and May 5, a period of 9 days, showed practically no population of weeds when the treatments had to be applied. It can be noted from the weather chart that the temperatures during this time were well below normal. The rainfall during this same period was also very low. In order to successfully test materials for pre-emergence weed control, the general impression is that there should exist a good population of weeds at the time of treatment. Since a weed population was not present, it was rather surprising that satisfactory control was obtained throughout the seedling or blocking and thinning stage of the beets. The final weed population was counted June 16, or 41 days after the treatments were made.[3] The species of weed encountered were mostly lambs quarter, crab grass, plantain, purslane, smart weed, and ragweed. Later in the season plantain no longer seemed to be a factor and red root came in rather strongly.

Table 1. Series I. Pre-emergence Weed Control in Sugar Beets--Materials Used and Degree of Control.

Code	Material	Dosage: Per acre applied in 50 gallons of water	Weed Population May 24	Weed Population June 16*	Beet Stand. Inches containing beets in 100 inches	Condition of beets
ACX 258	Aromatic Oils	12½ gal.	97	92.9*	22.5	N.**
"	" "	25 gal.	60	55.2	19.3	M.S.
"	" "	50 gal. No water	31	35.2	10.3	V.S.
ACX 235	10% Pentachlorophenol in aromatic oils.	2½ gal.	77	68.3	27.0	N.
"	"	5 gal.	44	56.1	23.0	N.
"	"	10 gal.	20	41.2	13.8	M.S.
"	"	5 gal. as concentrate	35	41.2	20.0	N.
ACX 244	5% dinitro phenol in aromatic oil	2½ gal.	90	112.1	25.5	N.
"	"	5 gal.	31	40.5	19.3	M.S.
"	"	10 gal.	16	31.1	17.3	V. S.
"	"	5 gal. as concentrate	73	69.8	21.0	M.S.
Ck.	No treatment	---	261	168.5	27.0	N.

*Average numbers of weeds in 10 one-foot squares in each of 3 replicates
Land fitted for seeding April 26th, planted May 4, plots treated May 5, beets emerged May 17.

** N. - Normal
S.S. - Slightly stunted
M.S. - Moderately stunted
V.S. - Very stunted

[3]The identification of weeds was made by Mr. H. A. Runnels of the Ohio Experiment Station.

The counting of weeds was by one foot square areas which were selected at random by tossing a one-foot wire frame in the plot being counted. Wherever the square landed, that area was taken. The plots were in triplicate and ten counts were made in each plot. Ten squares to each plot would, therefore, represent 30 one-foot squares for each count.

Perhaps it should be explained further that the standard materials selected for this timing series were those that showed promise in some preliminary tests and have been more commonly used in other selective weed control experiments. The two general chemical compounds, pentachlorophenol and the dinitrophenol group, have been particularly effective in certain roles of weed killing. Preliminary results also indicated that certain types of aromatic oils enhanced the efficiency of these materials and at the same time did not increase their injury factor to the crop seedling. The aromatic oil alone gave rather excellent reduction in the weed population when used during the pre-emergence stage. The weaker dosages, 12½ gallons or even 25 gallons per acre, were partially effective, whereas the 50 gallons applied per acre eliminated almost all of the types of weeds present. However, the stand of beets was also decreased as the oil was increased and what beets did come up were abnormal. In general, the beet seedlings grew out of this stunted condition and later were nearly normal.

The 10% pentachlorophenol in aromatic oil at 5 gallons per acre reduced weeds considerably and the 10 gallons gave a very satisfactory reduction. When this same material was used at the rate of 5 gallons per acre as a concentrate, that is without water, it was about the same as when the 5 gallons were used diluted to 50 gallons. When 5 gallons of material are applied per acre with a hand sprayer there must be considerable variation. Such experiments would best be handled by mechanical devices eliminating the human element. The stands of beets and the condition of the beets were little affected by increasing the dosages of 10% pentachlorophenol formulation up to 10 gallons per acre.

The 5% dinitrophenol in aromatic oil proved also to be an excellent weed killer when applied during the pre-emergence stage. It will be noted from the weed counts that it reduced the population more effectively than either aromatic oil alone or the pentachlorophenol fortified with aromatic oil. During this early test, it did not reduce the beet stands materially, but did injure the young seedlings. When 5 or 10 gallons of material were used per acre, there was hardly a normal beet plant. In later experiments, this injury became even more severe.

The beet stands given in Table 1 are low when compared with normal good stands. In the first place, the planting was done with the Milton single seeder and the seeder set for a 2-inch spacing. Beet stands are tabulated as inches containing beets in 100 inches of row and were evaluated by making ten 30-inch counts taken at random in the two center rows of each plot. With a two-inch spacing, 100 inches of row could show only 50 beets; therefore, a perfect stand of such a planting would be 50. Moreover, the drill was new and was not properly worked in nor adjusted for all the conditions existing in this seed bed. The important cause for erratic planting, in addition to the seeder discs not running because of mechanical imperfections and newness, as explained earlier was that it would not plant continuously when the soil was in the uneven condition present in this first area. Therefore, poor stands

were obtained throughout this first planting and the beet stands are not particularly significant. Much more significance could be placed in this case on the general appearance of the plots and this is the primary basis for the deductions presented in the discussion of the results.

The general conclusion from results given in Table 1 is that there are conditions under which pre-emergence weed control can be used on beets, even though the temperature is below normal and the germination of weeds and beets alike is delayed. The results also seem to give some evidence that the effect of chemical pre-emergence weed killing compounds last over a considerable period of time.

Table 2. Series II. Pre-emergence Weed Control in Sugar Beets -- Materials Used and Degree of Control.

Code	Material	Dosage: Per acre applied in 50 gallons of water	Weed Population June 2	Weed Population June 16*	Beet stand. Inches containing beets in 100 inches	Condition of beets
ACX 258	Aromatic oils	12½ gal.	83	86.3*	34.3	N.**
"	" "	25 gal.	14	38.7	28.0	N.
"	" "	50 gal.	10	28.0	28.3	S.S.
		no water				
ACX 235	10% Pentachlorophenol in aromatic oils	2½ gal.	22	36.7	37.4	N.
"	Ditto	5 gal.	10	24.0	27.3	N.
"	"	10 gal.	8	22.0	25.5	S.S.
"	"	5 gal. as concentrate***	29	44.0	26.3	S.S.
ACX 244	5% dinitro phenol in aromatic oil	2½ gal.	9	25.7	20.6	N.
"	Ditto	5 gal.	6	13.3	12.7	M.S.
"	"	10 gal.	3	6.3	2.7	V.S.
"	"	5 gal. as concentrate***	4	18.0	14.0	N.
Ck.	No treatment	---	121	123.0	33.0	N.

*Average number of weeds in 10 one-foot squares in each of 3 replicates.

***Applied without water.

Land fitted for seeding May 4, planted May 19, plots treated May 19, beets emerged May 26.

** N. - Normal
S.S. - Slightly stunted
M.S. - Moderately stunted
V.S. - Very stunted

Medium-Planting Timing Series

The results given in Table 2 represent the second timing of beet planting. When the experiment was first arranged, it was hoped that this series might have been planted around May 10, which would be a more normal time for beet planting in general. Owing to the slowness of the season and wet ground, delay had to take place. The land was fitted May 4 and planted May 19. This delay was necessary because no weeds seemed to come up after fitting. It will be noted from the weather chart that the temperatures remained somewhat below normal during the period. Conditions were not favorable for growth.

The surface part of the soil became very hard-crusted during the period from fitting to planting, a space of 15 days. It was practically impossible to sow the beets so that they would be covered sufficiently for germination. After several attempts, the drill was weighted down with several hundred pounds of fertilizer and a somewhat better sowing was obtained. The overall stand of beets obtained was fairly good, especially where the soil was even and the drill operated uniformly.

Results of the Medium Planting Series

The results obtained with the three formulations were very satisfactory and were not much different than those explained in Table 1. Again the dinitrophenol formulation gave severe injury and this time reduced the stand down to almost nothing. The plots receiving 10 gallons remained almost bare at the conclusion of the experiment July 1st. Even the medium dosage of 5 gallons caused severe injury and reduction in stand. It probably should be pointed out that the dinitrophenol group compounds caused less damage when the weather and soil were colder than it did under higher temperatures. Weed control during this second timing period seemed to be more effective for all the formulations used than during the earlier planting.

Late Timing Series

Again the planting was later than was anticipated; materialization of a usable weed population was always awaited. While the temperatures between the fitting time on May 20 and the emerging time on June 18 were higher, the moisture conditions were deficient and the weed population again failed to materialize. Since only a photographic record was taken of this series, no table is included.

Results

The higher concentrations of all materials used practically eliminated weeds. This may have been due to the low population of weeds to start with and the increased temperature. Most chemicals are more active as temperatures rise. On the other hand, the beet stands were normal in the untreated plots and were normal in nearly all of the plots except the high dosage of oil and almost all treatments of the dinitrophenols. It will be noted in this case that no beets came up at all in any of the plots treated with the latter, except the 2½ gallon treatment.

The striking part of this series is the complete bareness of the plots treated with the dinitrophenol compounds. The pentachlorophenol in aromatic oil gave practically complete control of weeds with the lowest dosage (2½ gal. per acre) and only a slight reduction in beet stand even at the highest dosage.

(10 gal. per acre).

Under the conditions of this experiment, none of the timing experiments gave injurious results from pentachlorophenol in aromatic oil for pre-emergence treatments on beets, although they gave satisfactory weed control. It is admitted that, in general, the weather was cold and dry and perhaps if the reverse were true, namely warm and wet, different results might be obtained. It was definitely proven that the dinitrophenols are too injurious to be used in the pre-emergence weed stage for beets. The same is true to a somewhat lesser extent with aromatic oil alone.

Spray Application Timing

One of the important considerations in pre-emergence weed control by chemical application is the timing of the spray applications in respect to the planting or emergence of the crop. A single experiment was set up to study this phase. There were two major objectives: (1) to determine relative injury resulting from spray application as emergence of the beets approached, and (2) to determine relative effectiveness of the spray materials with increasing time for weed development.

Materials

The same materials were used as those used in the planting date series--aromatic oil alone and with pentachlorophenol and dinitro ortho secondary butyl phenol fortifying agents. In addition to the single concentration of fortifying agent in the aromatic oil, four concentrations, ranging from one and one-fourth percent to 10% by weight of the chemical in oil were used. Each of the formulations were then applied at three dosages ranging from 1 1/4 gal. per acre to 5 gal. per acre. The objective was to determine if possible the optimum concentration of toxicant in the aromatic oil and the dosage response both on weed control and on injury to the beets.

Soil preparation, planting, etc.

The sugar beets used for this work were planted May 20 in soil prepared at the same time (May 4) as the second "planting timing" experiments. The same planting, weed growth, and other conditions described previously for the second planting experiment pertained to this planting. As a result a fairly uniform although not complete stand of beets was obtained.

Procedure

It had been planned to make applications at three timings with respect to planting: (1) on the same data as planting, (2) two days after planting, and (3) four days after planting. Because of unfavorable weather conditions it was not possible to make an application either on the same day or the day following planting. However, the two-day and four-day timings were applied. Since the beets emerged six days after planting these applications were timed to four and two days before emergence, respectively. The entire experimental set-up and results are given in Table 3.

Table 3. Pre-emergence Weed Control in Sugar Beets with Aromatic Oil, Pentachlorophenol in Aromatic Oil, and Dinitrophenol in Aromatic Oil.

Plot No. S-	Material	Dosage: Per acre gallons applied in 50 gal. of water	Timing days before emergence	Weed Population June 13	Weed Population June* 17	Sedges (not in total)	Beet stand
1	258 Aromatic oil	6 1/4	4	100	92*	5	30.3
4			2	123	85	2	37.3
2	258 " "	12 1/2	4	82	54	9	37.3
5			2	61	53	8	37.3
3	258 " "	25	4	23	35	0	42.0
6			2	15	20	5	37.3
7	Check	-	-	281	-	-	30.0
11	238 1-1/4% Pentachlorophenol in aromatic oil	1 1/4	4	123	110	7	45.0
14			2	184	114	2	39.3
12	238 Ditto	2 1/2	4	131	108	1	41.0
15			2	175	138	5	37.4
13	238 "	5	4	118	66	0	39.3
16			2	146	113	3	33.0
17	Check	-	-	269	-	-	41.0
21	237 2½% Pentachlorophenol in aromatic oil	1 1/4	4	122	96	10	39.0
24			2	202	148	1	35.7
22	237 Ditto	2 1/2	4	144	119	4	40.3
25			2	187	119	14	33.0
23	237 "	5	4	85	65	0	36.3
26			2	70	69	1	37.3
27	Check	--	-	190	-	-	37.7
31	236 5% Pentachlorophenol in aromatic oil	1 1/4	4	117	102	2	40.7
34			2	132	89	13	37.3
32	236 Ditto	2 1/2	4	163	112	35	34.7
35			2	113	92	2	36.3
33	236 "	5	4	60	55	0	32.0
36			2	57	28	0	33.0
37	Check	-	-	208	-	-	34.7
41	235 10% Pentachlorophenol in aromatic oil	1 1/4	4	141	95	23	45.0
44			2	149	103	4	37.3
42	235 Ditto	2 1/2	4	225	133	121	35.0
45			2	78	73	19	30.3
43	235 "	5	4	48	44	5	33.0
46			2	48	49	9	31.3
47	Check	-	-	255	-	-	32.3

Table 3 (continued)

Plot No. S-	Material	Dosage Per acre gallons applied in 50 gal. of water	Timing days before emergence	Weed Population June 13	Weed Population June* 17	Sedges (not in total)	Beet stand
51	246 1 1/4% Dinitro phenol in aromatic oil	1 1/4	4	131	120*	21	35.0
54			2	208	115	17	29.7
52	246 Ditto	2 1/2	4	271	114	228	38.0
55			2	124	98	5	35.3
53	246 "	5	4	64	87	00	35.3
56			2	57	60	0	29.7
57	Check	-	-	243	-	-	35.9
61	245 2½% Dinitro phenol in aromatic oil	1 1/4	4	191	136	15	41.3
64			2	175	126	29	35.5
62	245 Ditto	2 1/2	4	300	115	266	35.9
65			2	53	61	0	33.0
63	245 "	5	4	59	43	0	33.3
66			2	52	76	0	31.7
67	Check	-	-	237	-	-	36.3
71	244 5% Dinitrophenol in aromatic oil	1 1/4	4	86	104	37	39.0
74			2	170	115	39	32.0
72	244 Ditto	2 1/2	4	226	87	288	32.0
75			2	45	47	51	25.3
73	244 "	5	4	29	24	7	21.0
76			2	25	16	1	17.3
77	Check	-	-	207	-	-	35.0
81	243 10% Dinitrophenol in aromatic oil	1 1/4	4	75	51	35	39.3
84			2	82	90	93	32.3
82	243 Ditto	2 1/2	4	194	38	208	26.3
85			2	34	18	17	17.0
83	243 "	5	4	14	9	3	16.7
86			2	11	38	2	8.3
87	Check	-	-	222	-	-	35.0

*Average number of weeds in 10 one-foot squares
Land fitted May 5, beets planted May 20, beets emerged May 27

It is interesting to note from the results that the weed control was just as good from treatments made four days ahead of emergence as it was two days ahead of emergence. This would probably be expected in this case in view of the considerable period of time elapsing between preparation of the soil and planting, all of which time constituted the development period for the weeds. Likewise, the stand of beets did not seem to be affected at all by the delayed treatment except by the DN formulation. This is of considerable importance since it

indicates that spray treatment can be delayed to at least two days before emergence of the beets with safety to the beet crop and permit that much additional weed development with likelihood of more effective weed control.

It will be noted from Table 3 that the dosage used in this experiment were much less than in the timing series. The results seem to indicate that 5 gallons of 10% pentachlorophenol in aromatic oil per acre gave satisfactory control without injury to the beets. Any lower dosage than this was not too satisfactory. Also, the results indicate that weed control is almost in direct proportion to the quantity of the fortifying agent in the aromatic oil. In this case both with the dinitro and pentachlorophenol formulations the strongest concentration gave nearly the same control as the weaker concentrations when compared on the basis of an equal dosage per acre of the fortifying agent. The dinitro formulations gave injury in all concentrations where weed control was obtained. There seemed to be no margin between safety and effectiveness with these formulations. However, the results indicate more injury with this material the nearer it is applied to the time of emergence of the beets. Again, there was no difference in weed control in the two times of application. The aromatic oil alone gave effective weed control at the highest dosage without appreciable injury to the beets in this case.

In the section of the field where these plots were located, a heavy population of sedge appeared in two narrow strips running crosswise of the plots (low areas that remained wet for some time after a heavy rain. Most treatments had some effect in checking this weed, but general control was not obtained.

Special Treatments for Pre-emergence Weed Control in Sugar Beets.

The information in the preceeding sections of this report dealt with three materials what might be considered standard ones. They were aromatic oil, pentachlorophenol in aromatic oil, and the dinitro ortho secondary butyl phenol in aromatic oil. At the outset of this project, various companies were asked to submit any material that they might consider promising in pre-emergence weed control of beets. As a result about a dozen were supplied and were made up and used at various formulations and dosages. Since the reason for testing these new materials was exploratory and formulations were guesses no table of results is included.

These relatively new products had been previously tested in only a limited way. Several of these new compounds showed considerable promise and should receive wide testing in subsequent experiments. In general, there was very little injury to the beet stand and not much stunting or injury to the beet seedlings.

The Mechanical Blocking of Beets

The ultimate aim of this experiment, as indicated earlier, was to formulate a procedure or practice by which beets could be grown without hand labor. To accomplish this, there were three prerequisites. First, single germ or as nearly single germed segments of beet seeds were necessary. Such seed was available and used in these tests. Second, there must not be weeds with the seedling beets. Referring to the data given in the various tables, it will be noted that several treatments gave sufficient control of weeds so that no

subsequent hand labor was required to remove them. The plots treated with 10% pentachlorophenol in aromatic oil, at the dosages of 5 and 10 gallons made up to 50 gallons with water per acre, gave adequate control of weeds. This chemical treatment did not injure or impair the stand of seedling beets. From 30% to 40% stands were obtained which is adequate for cross blocking operations. Third, machines adaptable for mechanical blocking had to be available. The cultivator type of cross blocker as described earlier in this paper, was found suitable for this test. Plots were arranged as follows: Plots, 46, 56, 47, and 57 had stand counts of 35% to 40%. The treatments were as follows: 46, high pentachlorophenol concentrations; 56, low dinitro concentration; and 47 and 57 had no treatment. The cross blocker was pulled across these plots leaving a 4-inch block of beets and 8 inches cut out in between each block. These plots received no further hoeing, thinning or weeding.

The mechanical operation resulted in a satisfactory stand of beets where weeds were controlled. Stand counts and size of beets in the mechanically blocked series were as follows:

For treatment see Table 4	Average No. of beets in 4-row plot. Row 59 feet.	Average diameter of beets at harvest.
Plot 46	80	2.4 in.
Plot 56	61	2.3
Plot 47	42	.80
Plot 57	44	.75

Yields were not taken in this series. The entire field was cross-blocked only and where weeds were uncontrolled, the yield was practically nothing.

It seems possible that this type of weed control and cultural practice will make it possible to eliminate hand labor and to mechanically block the beets. It would become a crop, therefore, that would be handled much as any other crop.

Conclusions

It was well understood at the outset of this experiment that something had to be done for the beet industry or the growing of that crop would soon pass out of the agricultural picture in Ohio. The main objection to the growing of the crop is the hand labor necessary. It was further considered that this hand labor might be eliminated if the weed problem could be taken care of. It was for this reason that practically every type of chemical known by the authors to have herbicidal properties, and all the conditions that might be made to work, were tried out. It was realized that the weed population in early plantings might vary through the season and be quite different from those in late plantings. It was also realized that the soil and air temperatures might govern the safety or the effectiveness of control materials as the season progressed. It was for these reasons that the timing series was set up. It was also pointed out to the authors by those with earlier pre-emergence weed control programs that weeds had to be germinated or be in the seedling stage before control materials were applied. These requirements were complied with, limited only by existing conditions.

The final conclusions may be summarized somewhat as follows: The aromatic oil alone as used in this experiment was very effective in the control of weeds. However, as soon as sufficient dosages were used to give effective weed control, injury was obtained in most cases on the seedling beets. Hence, the results of the experiments indicate that there was an insufficient margin between effectiveness and safety for the use of this material alone for pre-emergence weed control for beets. Aromatic oils have been used in various types of weed controls for a number of years and it is known that they vary greatly in their structure and herbicidal properties. It was for that reason that in this experiment the Shell Oil Company was asked to furnish a uniform aromatic oil for the entire series of tests.

The second material used was pentachlorophenol (Monsanto Chemical Co.'s Santophen 20) in aromatic oil. That material gave excellent control of weeds when used at the rate of 5 to 10 gallons of a 10% solution. The 5-gallon dosage gave no visible injury to the beets in any of the plantings. The material gave good control regardless of the fact that there was a sparse population of weeds at the time of treatment. Pentachlorophenol is not toxic following rain because it is insoluble. This control or the influence of the treatment seemed to extend over a longer period than was anticipated. The general information available concerning the behavior of pentachlorophenol was that it soon breaks up in the soil and that its influence could not be expected to last more than a few days. Data was not found in the literature in this connection. The authors are of the opinion that the chemical may last somewhat longer or its effect on weed seed is over a longer period than for just the few days following treatment. However, the fact that it does not injure the young beet seedling as it comes up is further evidence that the chemical does not exert its effect over a very long period. It will require considerable more investigation before some of these points can be definitely determined.

CHEMICAL WEED CONTROL INVESTIGATIONS IN SUGAR BEETS AT FARGO, NORTH DAKOTA.

E.A. Helgeson, C. R. Swanson and L. M. Stahler.

An extensive program of chemical weed control in sugar beets was carried on during the past summer in cooperation with the United States Department of Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering and the American Crystal Sugar Company. About 600 plots, 4 rows wide and 10 feet long were treated in a commercial field near Moorhead, Minnesota, and in experimental fields of the American Crystal Sugar Co. at East Grand Forks, Minnesota. All treatments were in triplicate. Yields, sugar content, beet and weed stands were recorded.

I. Pre-emergence investigations

On plots located near Moorhead and East Grand Forks, applications of herbicides were made at 1, 2, 5, 6 and 8 days after planting. The results will be discussed below for each chemical used.

1. Cyanamid - Calcium cyanamid was applied as a dust at the rate of 75, 100 and 150 lb. per acre. There was no control of weeds and no injury to emerging beet seedlings.
2. Dinitro (Sinox General) - Applied at the rate of 1, 2 and 4 lb.

per acre at 5, 6 and 8 days after planting. The sugar beet stand was reduced somewhat especially in the 8 day treatment. There was good control of the broad-leaf and grassy weeds at East Grand Forks. At Fargo, weed control seemed good at first but weeds grew rapidly later. Samples of 15 beets each showed a definite reduction in weight with increasing concentration. Sugar percentages were normal with no differences due to rate of date of application.

3. Dinitro (Sinox W) - Same rates and dates of application as Sinox General. Sugar beet stand reduced noticeably on treatments 8 days after planting, with little difference between rates. There was some control of broad-leaved weeds at East Grand Forks and good control of wild mustard at Fargo. Weight and sugar tests were not taken.

4. Shell ACX-170 - Applied at the rate of 50 and 100 gal/acre on 5 and 6 days after planting. Beet stand reduced only slightly at 50 gallons but almost a 50% reduction at 100 gallons. Grass and broad-leaved weeds decreased 50% at 100 gallons. No noticeable control at 50 gallons.

5. ACX-184 - Applied at same rates and dates as ACX-170. Beet stand reduced to half at 100 gallons, no effect at 50 gallons. There was no noticeable grass weed control but some reduction in broad-leaved weeds at both 50 and 100 gallons.

6. Sodium pentachlorophenate (Dowicide G) - Applied in water at the rate of 4, 8 and 12 lbs./acre on 1, 2 and 5 days after planting. No noticeable effect on beets or weeds.

7. IPC - Applied at the rate of 2, 4 and 8 lbs./acre at 8 days after planting. No noticeable effect on beets or weeds.

8. Ammonium TCA - Applied at 6, 12, 24, 48 and 96 lbs./acre on 1, 2, 5 and 8 days after planting. Sugar beet stand was reduced with increasing concentration and with nearness of application to time of emergence. Beet stand at 96 lbs./acre was 50% of controls, at 6 and 12 lbs./acre the stand was not reduced appreciably. No such definite reductions were noted at East Grand Forks. Weedy grasses were reduced to an insignificant number at 48 and 96 lbs./acre and were badly stunted at the lower rates. There was some control of broad-leaved weeds at the higher rates. Beet weights were slightly lower than the controls except at 24 lbs./acre where the weight was considerably higher. Sugar content decreased only slightly from 6 to 96 lbs./acre treatments, and sugars did not differ greatly from controls.

9. Sodium TCA - Same rates and dates of application as ammonium TCA. Sugar beet stand was reduced with increasing concentration but not with nearness of application to time of emergence. Beet stand at 48 and 96 lbs./acre was 50% of controls, at 6 and 12 lbs./acre there was only a slight reduction in stand. Weedy grasses were reduced to an insignificant amount at 48 and 96 lbs./acre with severe stunting at lower rates. There was some control of broad-leaved weeds at the three higher rates. Beet weights were considerably lower than controls at the two highest rates and somewhat higher at the three lower rates. Sugar content decreased

very slightly from low to high application but did not vary much from controls.

10. Na 2,4-D - Applied at the rate of 1, 2 and 4 lbs./acre at 1 day after planting. A few sugar beets survived in each application but they were severely malformed. All weeds except the grasses and smartweed were well controlled.

II - Post-emergence

These plots were located on the field near Moorhead. Applications were made immediately after blocking, 3 weeks and 6 weeks later. Pigeongrass and wild oats were the only weeds prevalent.

1. Shell ACX-184 - Applied at the rate of 16, 32 and 64 gal/acre. There was considerably more injury to beets when sprayed immediately after blocking than when sprayed 3 weeks later. Injury to beets ranged from 30% kill at 16 gal/acre to 65% kill at 64 gal/acre. No control of grassy weeds. Beet weights were inconsistent and sugar content decreased slightly with increasing rate of application.

2. ACX-170 - Applied at the same rates and dates as ACX-184. Injury to sugar beets by this oil was more severe especially when applied immediately after blocking. In this application there was 60% beet kill at 16 gal/acre and 100% kill at 64 gal/acre. Grasses, the only weeds present, were stunted at the two lower rates and most grass was killed at the highest rate. Beet weights decreased markedly with increasing rate of application but sugar content seemed unaffected.

3. NaCl - Applied at the rate of 40, 80 and 160 gallons of saturated solution per acre. There was some burning and pinching of sugar beet leaves but no weed control. Within each rate of application highest beet weights were on plots treated immediately after blocking, lower 6 weeks after blocking. Highest beet weights were noted for plots treated with 160 gal/acre and lowest for those treated at 40 gal/acre. Sugar, however, was highest for the lowest rate of application with very little difference between the treatments.

4. KCl - Applied at the same rates and dates as NaCl. There was no injury to beets and no weed control. Weight of beets as only slightly lower than controls and showed no relation to rate or date of application. Sugar percentages were equal to those of controls and showed no relation to rate or date of application.

5. NaTCA - Applied at the rate of 4, 6, 8 and 16 lbs./acre. There was definite chlorosis of beet leaves at all rates and some pinching and burning at 16 lbs./acre. There was some twisting and stunting of grass weeds at the highest rate. Beet weights were lower than controls - those of 6 lbs. treatment the highest and those of 16 lbs. the lowest. Sugar percentages were only slightly lower than controls.

6. Ammonium TCA - Applied at the same rates and dates as NaTCA. The same gross effects on beets and weeds occurred as in NaTCA treatments. Beet weights were all lower than controls with the lowest occurring in plots

treated 3 weeks after blocking. Sugar percentages were slightly lower than controls and were slightly lower at higher rates of application.

7. Fortified oils (Shell ACX-262, 263, 264, and 265) - These oils contain 10, 5, 2.5 and 1.25% pentachlorophenol respectively. In general weedy grasses were injured at lower concentrations and killed at the highest, 64 gal/acre. The effect on beets was noticed almost immediately after treatment. The leaf blades drooped and appeared black within ½ hour. After 2 hours the leaves were charred. About 90 to 100% of the older leaves died within a day. Later the younger leaves made limited regrowth. The beet weight decreased with increase in chlorophenol with a yield of about ½ for the 10% fortified oil. Sugar content decreased with increase in rate of application for each oil.

An early dry spell followed by an extremely heavy rain storm during the period of germination and early emergence resulted in poor stands even in untreated controls and probably contributed much to the erratic and indefinite results obtained in most of the experiments recorded above.

WEED CONTROL IN SUGAR BEETS IN MICHIGAN

B. H. Grigsby, Michigan State College

Experimental work was planned in three stages, namely pre-planting, pre-emergence, and post-emergence treatments. Unseasonable weather, however, prevented our carrying out the entire program and we were able to secure data from the pre-emergence treatments only.

In the pre-emergence trials, light chemicals were used at two rates of application in randomized block, with three replications. The compounds were 2,4-D sodium salt, granular Cyanamid, Cyanate, a dinitrophenol, Stoddard solvents from two commercial sources, pentachlorophenate, TCA sodium salt, and IPC. These trials were made at two locations in order to secure soils of different character. One soil was a heavy clay, the other a light clay loam.

2,4-D, at 2 and 4 pounds acid equivalent per acre, and dinitrophenol, applied in water at 2 and 4 pounds of toxicant per acre, completely suppressed emergence of beets and prevented the growth of all annual weeds.

Cyanamid, at 75 and 100 pounds per acre, and Cyanate, at 25 and 50 pounds, reduced the stand of beets approximately 20 per cent and gave poor weed control.

Stoddard solvents did not significantly reduce the stand of beets and, when used at the rate of 50 gallons per acre, reduced the weed count by 75 per cent. Heavy growth of new weeds occurred, however, when these plots were blocked and cultivated.

Pentachlorophenate, at 4 and 8 pounds per acre, reduced the stand of beets 25 per cent and did not give satisfactory control of annual weeds.

IPC, at 4 and 8 pounds per acre, failed to control weeds and reduced beet stands 15 per cent. There were no grasses in this field as shown by weed plant growth in the check plots.

TCA was applied at the rates of 12 and 48 pounds per acre. The lower rate reduced weed plants 69 per cent and beet stand 27 per cent. At the higher rate of application, the degree of weed control was no greater than at the 12 pound rate and the reduction in number of sugar beet plants was approximately 80 per cent.

All plots were blocked and thinned, to the best stand possible, by hand and carried through to maturity by the normal tillage practices. Yield data, sugar content, and purity, were obtained.

On the heavy clay soil, when the yields were calculated to the average weight per beet, only the pentachlorophenate plots showed any significant difference in weight. A slight increase was found in this plot, perhaps due to the somewhat thinner stand and the consequent larger growth of remaining beets.

On the lighter soil, all treatments showed slightly greater size than the checks, with the greatest difference again in the pentachlorophenate plots, and for the same apparent reason.

Examination of the sugar analysis data shows that there were no significant differences between all treatments and the check, nor between the two rates of application. This lack of effect is important because of the indication, from the limited data of one season, that pre-emergence treatments with chemicals used, may not cause any physiological changes in beets which are reflected in the sugar content, which is, after all, the reason for growing sugar beets. Further trials are, of course, necessary before any definite statements, in this connection, can be made.

In some late season trials, 30 compounds, 20 of which were straight aromatic oils and oils fortified with various amounts of pentachlorophenol and dinitrophenols, were applied to beets planted in muck soil in which weeds had been allowed to germinate, before seeding. In these tests, all materials were applied as an emulsion at a rate of 10 gallons of the oil per acre. At this rate, severe reduction in beet emergence was found where the fortified oils were used. Weed control was satisfactory only in those plots where the actual amount of pentachlorophenol or dinitrophenol was 2 pounds or more per acre. The unfortified oils were not injurious to the beet seedlings but did not give a satisfactory control of broad-leaved weeds.

A repetition of this experiment, in which only 5 gallons of oil were applied, gave 100 per cent control of weeds where fortified oils were used, but stand counts of beets were not obtained because of a heavy frost on the much land. Emergence was just beginning when a hard freeze occurred and no further emergence took place.

Post-emergence sprays of ammonium sulfamate, sodium chloride, potassium chloride, Stoddard solvent, copper nitrate, and TCA were applied to beets in which a heavy growth of lambsquarter and red root pigweed was present.

Stoddard solvent, at 50 gallons per acre, gave complete control of the weeds, but the beets were injured so severely that recovery never occurred. Common salt and potassium chloride were ineffective on these weeds. TCA did not kill the weeds, although some defoliation of weed plants was apparent,

and did produce a marked stunting of the beets. The leaves of TCA treated plants developed necrotic spots within 24 hours and later growth had a very poor color, almost chlorotic in nature.

A 5 per cent solution of copper nitrate caused a rapid kill of both weeds and beet leaves. The crown of the beet plants was uninjured, however, and the affected plants made a quick recovery and soon made top growth which surpassed that of all other treatments and check plots.

These trials were made too late for the beets to reach maturity by the time harvests were made and no yield records or sugar analyses were made.

These trials are to be considered as exploratory in nature and the data obtained are of value only as they show which chemicals are not safe for use in beets, such as 2,4-D and dinitrophenols and as they give indications of chemicals which at other rates may possibly have some value in controlling weeds in beets. It is rather apparent that with the chemicals now available, pre-emergence treatments, even under conditions where advance fitting of seed bed cannot be done because of a short growing season, offer apparently the most feasible way for weed control in this crop. This should not, however, limit the continued search for compounds which may be used as a selective spray in the growing crop. In some areas, a pre-emergence control would not be sufficient because of the presence of late germinating species of weeds which can cause serious damage even after blocking and thinning operations have been completed.

WEED CONTROL FOR SUGAR BEETS - PRE-EMERGENCE WEED CONTROL STUDIES[1]

Russell T. Nelson[2]

In years past the sugar beet crop was used by many farmers as a means of arresting the spread of different weeds on their farms. Cultivation with row crop cultivators, supplemented with intense hand labor, was effective in reducing weeds. Presently, with the shortage of labor and the current trend toward mechanization, other methods of weed control are being sought.

It cannot be over-emphasized that in the case of diversified farming weed control should not begin or end with any one crop. Too frequently, only some crops of a rotation receive the attention of weed control. Under such a practice the reduction in weed populations obtained one year is restored in subsequent years. The progress being made in the control of weeds in cultivated and non-cultivated crops, and elsewhere, should through continued and expanded effort reduce the foulness of many of our fields.

Most crops have some intolerances to the mass treatment of weeds. Based on this degree of tolerance or intolerance, different crops, as well as different weeds, sometimes take on a peculiar aspect of control which again may

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[1]Contribution of the Beet Sugar Development Foundation, Fot. Collins, Colorado, and co-operating agencies.

[2]Agronomist, The Great Western Sugar Co. Experiment Station, Longmont, Colorado.

vary from one area to another. This report deals with pre-emergence control measures which were tested and observed by several members and associates of the sugar beet industry. The objectives were primarily to test and demonstrate those practices which would reduce, in particular, the hand labor requirements for controlling weeds in beet fields.

Non-selective sprays have been tested under several conditions where a weed problem existed prior to the emergence of beet plants. Certain materials used and results obtained for different locations are given in table 1. Several treatments were employed at only one location, while others were employed at two or more locations. The effects of treatments on stand of beets were secured by count at Longmont, Colorado; Mason City, Iowa; and Terminous and Lockford, California.

It is noted that many treatments were relatively ineffective in killing the weeds. Common contributing factors to the poor kill are (1) low toxicity of spray, (2) loss of material in atmosphere, (3) poor coverage, (4) weeds large, and (5) low temperature. It appears that most of the common diesel oils of today have a low phytotoxicity. They are good carries and have good spreading qualities, but their toxicity is greatly improved by the addition of even small quantities of oil-soluble herbicidal agents (e.g., the dinitro compounds).

Further treatments of pre-emergence contact spray, soil treatments, and severing of weeds just below the soil surface by mechanical means are listed together with results in table 2.

The results of pre-emergence contact spraying are generally more encouraging than the figures in terms of kill of weeds would indicate. In many cases the weeds were stunted and the beets emerged with more vigor and less competition than was the case on the unsprayed check areas. The subsequent weed elimination by hand labor was greatly facilitated, proyiding the work was begun within a reasonable period. The volume of material to be applied, its relative toxicity, and time of application are factors yet to be solved. In the case of controlling foul growth of volunteer small grains and wild oats in the Rocky Mountain areas, it appears that rather large quantities of oil are needed. The volume of material to be applied might well be governed by the amount that is required to saturate the foliage rather than employing any set rate. Preliminary trials indicate that a relatively non-toxic diesel oil can be sufficiently fortified by the addition of 1 pint Sinox General or its equivalent to 35 gallons of oil. In order to get kills, rather than mere burning of the foliage, the carrier (oil) must be applied in sufficient quantity to penetrate and carry the toxicant into the crown and lower portions of the plant.

The cost of pre-emergence spraying is high when such large quantities of oil are used. Spraying the area over and adjacent to the row is a practical means of reducing the cost of materials for pre-emergence contact spraying of sugar beets. Shields are effective in holding down the spray and fog and are of particular advantage if spraying on windy days.

The oils with considerable residue, such as SHELL WEED KILLER No. 20, tend to stop up the fine nozzles needed for application and have a tendency toward greater residual effects which endanger the crop.

At present, methods of mechanical control are used more widely than those of chemical control. The acceptance of modifications in tillage practices has been rapid as a result of the good control of weeds which has been obtained. Utah-Idaho Sugar Company reports that the use of the finger weeder just after germination is well underway has given up to 90 per cent control of early spring weeds in the Chinook, Glasgow and Great Falls districts of Montana. They also report weeds were 50 per cent less on ridge-cover versus flat planting.

Growers for the American Crystal Sugar Company ridge-cover planted 14,000 acres of beets in the Red River Valley during 1948 with good success. This was used primarily for the conservation of moisture in the area of the seed but also helped in the control of weeds. The practice of growing biennial sweet clover for green manure and fallowing part of the season prior to the beet crop likewise aids in weed control and storage of moisture in that area.

Several methods and tools are used in the mechanical control of weeds in beet fields before and after the beets are planted. After the seed bed is prepared and before planting, cultivator knives may be used with success in cutting all present weed growth with a minimum of loss in soil moisture. After planting, finger weeders, spider weeders, and similar tools may be employed with success. The drawback to these tools this past spring was that they increased soil moisture loss under some conditions. When moisture is critical, these tools should be used with caution. Some down-the-row tools may be used without losing the position of the drill rows. This is important if one should want, or need, to apply a surface irrigation before the beets are up.

Table 1. Results of pre-emergence contact spraying at 9 locations given as percentage kill of broad-leaf (Br) and grass (Gr) plants, and stand of beets (Bts) in per cent of check.

No.	Treatment per acre	Ft. Collins Colorado			Longmont Colorado			Rocky Ford Colorado		
		Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts
	Oils, straight and fortified:									
1.	Diesel oil, 40 gal. (Local, low A.P.I. gravity)	37	58	U		14	121	12	24	U
2.	Diesel oil, 20 gal. (Local, low A.P.I. gravity)	7	50	U						
3.	Diesel oil, 40 gal. + Sinox Gen.* 1 qt.	67	84	U				91	51	Sl.I
4.	Diesel oil, 20 gal. + Sinox Gen. 1 qt.					19	111			
5.	Diesel oil, 10 gal. + Sinox Gen. 1 qt.					25	135			
6.	Diesel oil, 40 gal. + Sinox Gen. 1 pt.	60	100	U				93	59	U
7.	Diesel oil, 20 gal. + Sinox Gen. 1 pt.					26	117			
8.	Diesel oil, 40 gal. + 8.8 Lbs. PCP, phenol	79	79	U						
9.	Diesel oil, 40 gal. + 4.4 Lbs. PCP, phenol	79	100	U						
10.	Diesel oil, 17 gal. + 3 Gal. Shell #30 Weed Killer**				No broadleaf plants present	34	106			
11.	Diesel oil, 40 gal. (Calif. Standard Oil #2)	33	100	U						
12.	Diesel oil, 20 gal. (Calif. Standard Oil #2)	0	17	U		11	107			
13.	Diesel oil, 10 gal. (Calif. Standard Oil #2)									
14.	Shell #20 Weed Killer, 40 Gal.	96	100	U				81	78	I
15.	" " " " 20 "	81	67	U		23	100	—	1	
16.	" " " " 10 "									
17.	Stoddard Solvent, 20 gal.					0	99			
	Oil-water Emulsions (fortified):									
18.	Diesel oil, 20 gal. + water, 60 gal. + Sinox Gen., 1 qt.									
19.	Diesel oil, 20 gal. + water, 60 gal. + Sinox Gen., 1 pt.									
20.	Diesel oil, 10 gal. + water, 30 gal. + Sinox Gen., 1 pt.							100	56	U
21.	Diesel oil, 10 gal. + water, 30 gal. + Sinox Gen., 1 qt. + S.E.B. 1 qt.***					20	117			
22.	Shell #20 Weed Killer, 20 gal. + water, 60 gal. + S.E.B. 0.4 gal.									

Table 1. (continued)

No.	Treatment per acre	Ft. Collins Colorado Br	Gr	Bts	Longmont Colorado Br	Gr	Bts	Rocky Ford Colorado Br	Gr	Bts
23.	Shell #30 Weed Killer, 8 gal.+ water,.32 gal.	63	90	U						
24.	Shell #30 Weed Killer, 4 gal.+ water,.36 gal.									
25.	Penta 9 gal. (Chapman Chem.Co.) + water 31 gal.	94	93	U						
26.	Penta 6 gal. (Chapman Chem.Co.) + water 34 gal.	84	97	U						
27.	Penta 3 gal. (Chapman Chem.Co.) + water 37 gal.	42	100	U						
	Aqueous Solutions:									
28.	PCP, Sodium salt, 25 lbs.+ water, 40 gal.	35	7	U						
29.	PCP, Sodium salt, 50 lbs.+ water, 40 gal.	67	100	U						
30.	PCP, Sodium salt, 25 lbs.+ water, 130 gal.							95	0	I

U - Uninjured Sl.I - Slight Injury I - Injured definitely

* Active ingredient 75% dinitro ortho secondary amyl phenol

** Contains in oil 1.12 lbs. per gal. of PCP (pentachlorophenol)

*** Calif. Standard Oil Emulsifier Blend #50724-R

No.	Location: Mason City Iowa Br	Gr	Bts	Chaska Minn. Br	Gr	Bts	Terminous Calif. Br	Gr	Bts	Lockford Calif. Br	Gr	Bts	Woodland Calif. Br	Gr	Bts	Sheridan Wyo. Br	Gr	Bts	Ave. Br	Gr
1	60	66	122	75	75		94	59	126	65	30	32	85	80		37	0		58	45
2							51	0	132	46	26	58	65	56		28	0		39	26
3	95	84	103	100	91		94	68	108	80	92	9	90	94		97	74		89	80
4																84	0			
5																				
6	95	87	135	100	92		91	65	104	90	63	0	91	83		94	58		89	76
7																				
8																				
9																				
10																				
11																58	3			
12							96	83	129	73	65	5	91	75		47	0		61	42
13							61	33	94	37	0	19	86	52						
14																85	38			
15	89	46	125				90	57	121	68	69	25	90	60		71	0		81	46
16							52	0	114	57	59	26	69	20						
17																				
18							75	39	115	87	76	0	98	79					87	65

Germination very poor due to drouth

Poor germination conditions, no beets

Germination limited by drouth

Table 1. (continued)

No.	Location: Mason City Iowa			Chaska Minn.			Terminous Calif.			Lockford Calif.			Woodland Calif.			Sheridan Wyo.			Ave.	
	Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts	Br	Gr
19	94	86	97				65	0	111	58	76	13	92	70					77	58
20	[illegible]	61	107	100	94															
21																				
22																91	0			
23																98	0			
24																92	2			

Table 2. Results of pre-emergence contact spraying, of amendments to seed bed, and severing of weeds with shallow tool given as percentage kill of broad-leaf (Br) and grass (Gr) plants. (Injury to beets not noticed except where indicated with asterisk).

Treatment (Rate per Acre)	Location: Ft. Collins Br	Gr	Bts	Rocky Ford Br	Gr	Bts	Mason City Br	Gr	Bts
Pre-emergence contact spray:									
K isopropyl Xanthate, 20 lbs. + 40 gal. water	53	33							
K isopropyl Xanthate, 50 lbs. + 40 gal. water	21	100							
TCA, Sodium salt, 100 lbs. + 40 gal. water	36	37	*						
TCA, Sodium salt, 200 lbs. + 80 gal. water	80	75	*						
TCA, Ammonium salt, 100 lbs. + 40 gal. water	57	71	*						
TCA, Ammonium salt, 200 lbs. + 40 gal. water	55	50	*						
Ammonium thiocyanate 50 lbs. + 40 gal. water	67	64							
Ammonium thiocyanate 100 lbs + 40 gal. water	75	75							
Ammonium sulfate 100 lbs. + 40 gal. water	0	0							
2,4-D ester(isopropyl) 2/3lb. + 40 gal. water	11	0							
Flaming (weed burner)				67	11				
Materials below worked into soil ahead of planting:									
Areocyanamid, 200 lbs.				11	12		0	0(a	*
IPC, 4 lbs.				4	0		0	0	

Table 2. (continued)

Treatment (Rate per Acre)	Location								
	Ft. Collins			Rocky Ford			Mason City		
	Br	Gr	Bts	Br	Gr	Bts	Br	Gr	Bts
TCA, Sodium salt, 25 lbs.				17	0		0	0	*
TCA, Sodium Salt, 100 lbs.				58	24		0	0	*
Shallow Cultivation ahead of planter:									
Rotary Hoe (garden weeder)				87	65				

* Beets and stand suffered adversely as result of treatment.
(a Soil moisture was very low at Mason City during test.

POST-EMERGENCE WEED CONTROL (MECHANICAL)

E. P. Pattison - Holly Sugar Corporation

In addition to sound cultural practices in soil preparation, we are endeavoring to further reduce weed population in the sugar beet crop which, when accomplished, will in turn eliminate the need for hand labor in obtaining a profitable yield.

In recent years when a shortage of hand labor was a constant threat to the industry, numerous devices and methods have been experimented with by Sugar Companies in cooperation with the Beet Sugar Development Foundation, which is an organization supported by all Sugar Companies in an effort to evaluate new practices and machines and when proven, promote their universal adoption.

In presenting these data, a summary of this work by several companies will be given by listing first, mechanical devices and the results obtained from their use, followed by a resume of work done with selective herbicides.

The weeder mulcher has attained great popularity among growers in reducing the number of man hours required in thinning and hoeing of their crop. This device is sometimes referred to as the pencil weeder or bean weeder and consists of long, round, tapered teeth, which have a spring-like action when drawn through the soil. These teeth are known as Hallock type teeth. The jerky spring action in the ground permits this tool to be the most effective when used at speeds not greater than two miles an hour. These implements, which range in price from $40.00 to $125.00, are manufactured by upwards of sixteen firms.

Tests have been run in nearly all the beet growing areas. A common practice in these tests was to plant approximately five pounds of processed seed in order to insure sufficient emergence to permit frequent operations of the weeder mulcher at a time when weeds were easily dislodged. A uniform stand is of the utmost importance in the use of any mechanical device.

Usually the machine was used crosswise or diagonally across the row for the first two or three times, depending on the reduction of the stand. In treating larger beets, namely, eight leaves, the device was used up and down the row. This was especially true in the Saginaw area. Typical figures on reductions of weeds and plants, when beets were in the 4 to 6 leaf stage, show a 9.1% reduction of beets while the reduction of weeds shows 30.4%. These figures were taken from the Spreckels Sugar Company's tests in California. In several cases in the Rocky Mountain area, as high as 50% of the weeds have been removed with one operation of the weeder mulcher. Two operations of the weeder mulcher showed a reduction of 549 plants per 100 feet of row with a 90% reduction of weeds in a test run by Holly Sugar Corporation at Grand Junction, Colorado. The second operation was performed two weeks after the first operation. Two machines used, that most growers have on hand, have been the common spike tooth harrow and the side delivery rake. The availability of these machines makes them extremely popular in some areas. The spike tooth harrow, in some cases, has been mounted on wheels in order that the depth may be more easily regulated. The use of this machine may be slightly more severe than that of the aforementioned weeder mulcher; however, with some care, very satisfactory results have been obtained. In Saginaw, Michigan, a planting of 5½ pounds of segmented seed per acre was treated with one operation of the harrow and subsequent stand counts proved that there was still a sufficiently good stand to permit the use of the weeder mulcher.

Utah-Idaho Sugar Company's experiments indicated that beet stands were not reduced more than 10% to 12% when cross harrowing was done within the 4 to 8 leaf stage and that weed populations can be greatly reduced with no appreciable injury to the beet stands.

The use of the side delivery rake has proven equally as effective in some cases, especially at Grand Junction where the weed population was reduced 90% with a similar reduction of plant population, as that of the weeder mulcher. Utah-Idaho reports that the side delivery rake was used for the first time when other tools were being used for the second time; in other cases, when the beets were still in the cotyledon stage and in other instances the rake was used rather satisfactorily, as far as weed control was concerned, after the beets had obtained their true leaves. It was very evident in all cases, however, that if we were to get a reduction in beet population through the use of the side delivery rake, the rake would have to be used while the beets were very small. The 4-bar side delivery rake is more satisfactory than the 3-bar, inasmuch as it gives smoother performance. As the side delivery rake is used down the row, in some cases the wheels of the rake had to be adjusted so that they would fit between the rows, and in some other cases it was difficult to lower the teeth sufficiently to get the proper amount of contact between the teeth and the soil. In view of these difficulties, most farmers were less enthusiastic about the side delivery rake than they were about the weeder mulcher in the Utah-Idaho district. On hard soils, farmers felt the operation was rather hard on the side delivery rake and that excessive wear would result.

Spreckels reports that in California, with their heavier soils, their tests with the side delivery rake were not successful, as their soils require more severe treatment than the side delivery rake can give. The tines were unable to penetrate more than 1/4" to 1/2" into the soil. If the speed over the ground was in excess of approximately two miles per hour, the tines

bent readily. On any but power take-off side delivery rakes, the speed of the reel in relation to the speed over the ground is not great enough.

Tests with the Wind Power Ro-Tiller (Model R-1), which has action similar to that obtained from the side delivery rake, except that it is concentrated over each row, showed that in the Utah-Idaho territory this tool was most successful when used when the beets were small, either in the cotyledon stage or when they were just getting their first set of true leaves. However, it was still possible to do considerable work with the Ro-Tiller when the beets reached the 6 to 8 true leaf stage, if a precision cultivation job was given first. It was noted, especially in Montana, that on heavy gumbo soils the Ro-Tillers were not heavily enough built to stand up under the stress to which they were subjected. It was felt that this tool could be given much wider use than was made of it this past season.

The Dixie Cotton Chopper Adaptation: A great many local adaptations have been worked out to adapt the spring weeder principle to this machine, which is one of the oldest devices used in the mechanization of the sugar beet crop. The original machine, called the Dixie beet thinner, was equipped with knives for the purpose of mechanically thinning beets by blocking the plants at adjustable intervals. This machine did not receive wide-spread acceptance as a mechanical thinner; however, as most of the Sugar Companies have a number of these machines, they have endeavored to modernize this implement with the result that this down-the-row machine has done a very acceptable job, the only objection being it is only capable of taking two rows at a time, necessitating extra tractor work, which has a tendency to pack the field. The first of these devices was one made up of four baler pick-up teeth attached to the cutter head. These were found to be too light for post-emergence work but did have a place in pre-emergence weeding. Professor Barmington, of Colorado A. & M. College, developed a similar device consisting of spring wire attached in a similar manner to the cutter head. This device, being a little more severe, was readily adapted to post-emergence work. The Dixie Company devised a rod weeder which they use successfully in cotton and which has been used successfully in sugar beets for post-emergence weed removal. In order to combine both weed and stand reduction, the Holly Sugar Corporation devised a hook weeder, consisting of eight rods bent and sharpened in the form of a hook at the end. This device proved very satisfactory in trials at Grand Junction in weed reduction and has gained popularity in other territories in the United States and Canada. In California, Spreckels Sugar Company experimented with the Dixie beet thinner using an Eversman weeder head. This tool operates at right angles to the row. It either hits beets and weeds cleanly or misses them cleanly. There is little dragging or mangling of the plants. In these trials, only one of the mechanical weeder tools showed promise under their conditions. The Dixie beet thinner, with the Eversman weeder head, is capable of doing moderately good, even weeding and pre-thinning under the proper conditions.

Bull-Tongues or Chisel Points: A method which makes use of four different point widths. This method has been used near Toppenish, Washington, mainly as a control for the late developing water grass, but is equally satisfactory for the earlier growing weeds. Immediately after thinning, a very narrow chisel is run shallow and close to row. In next cultivation a chisel about 1-1/2" wide is used. Two weeks later a 2-1/2" chisel, then finally a 4"

chisel or bull-tongue. In addition to this method, a winged ditching shovel, to break out the center of the row and push still more soil under the leaves and around the beets, can be used, following the use of a weeder mulcher. As the season progresses, the size of this shovel is increased until the time the beets are gone through the last time, which is usually a 15" winged shovel. This procedure makes very deep irrigation furrows and also hills the soil well up around the beet crowns. Irrigation is handled in such a way that the top of the beet row never gets wet. This helps to prevent weeds from germinating in the row in later season.

The Eversman Manufacturing Company has developed a weeder head for their blocker, which is referred to earlier as being adapted to the Dixie beet thinner. This weeder head, when used on the Eversman blocker, has similar action to that of all spring weeders. This machine is a down-the-row, four-row device, which operates directly over the row and has proven successful in the Grand Junction tests in very satisfactorily reducing weed population.

SUMMARY OF MECHANICAL SUGAR BEET AND WEED ELIMINATION IN THE CHINOOK DISTRICT

Treatment	Pre-Treatment No. of Beets	Pre-Treatment % Beets	Post-Treatment No. of Weeds	Post-Treatment % Weeds
John Deere Rotary Hoe				
Factory Farm	88	46	123	66
Pintler Farm	55	32	1	6
Side Delivery Rake				
Factory Farm	48	24	103	55
Pintler Farm	50	30	3	19
Ro-Tiller				
Factory Farm	30	14	59	31
Pintler Farm	43	25	4	25
Frisch Farm	15	13	164	41
Porter Farm	79	42	42	50
Dixie Thinner				
Glazier Farm	437	68	16	59

TABULATION OF RESULTS OF COUNTS MADE AT OTTO NISSEN FARM
GRAND JUNCTION, COLORADO - 1948

	May 8		2nd Operation May 29			
	Plants per 100 feet	Weeds per 50 sq.ft.	Plants per 100 feet	*Weeds per 50 sq.ft.	Per cent reduction Beets	Weeds
Dixie	792	29	154	3	80.5	89.6
Hand	732	37	120**	11	83.6	70.3
Eversman	828	61	134	1	83.8	98.3
Cropmaster	660	42	157	6	76.2	85.7
Side Delivery Rake	780	63	173	10	77.8	84.1
Weeder Mulcher	744	52	195	7	73.8	86.5

* Weeds per 50 sq. ft. Calculation is based on 50 one-foot square counts made along the row.
** First operation.

POST-EMERGENCE WEED CONTROL (SELECTIVE SPRAYING)

E. P. Pattison - Holly Sugar Corporation

Post-emergence salt spray. In 1947 Holly Sugar Corporation carried out a small scale test using 200 pounds per acre of common stock salt (NaCl) on a field infested with broad-leaf weeds (mainly red root) and grasses. The results were such that this year a larger scale operation was carried out in the Fountain area south of Colorado Springs, Colorado. This field in which the test was carried out was one which was abandoned due to an abnormally bad infestation of all types of broad-leaf weeds and grasses. This presented an excellent opportunity to try various rates and methods of applications of salt.

The field was divided into plots and records kept of each treatment. Two methods of application were used as follows: Iron Age sprayer, single 0 orifice nozzle open 6" above beets and two 00 nozzles spaced 24 inches apart lengthwise of the row under four foot hood one to two inches above foliage, the latter covering approximately a six inch strip of row directly above the beets. One foot squares were used to determine the effect of the application on the weeds as well as the beets, the latter being in the 6 to 10 leaf stage. Counts were made prior to application as well as three counts made 24 hours, 48 hours and one week following applications.

Roughly summarizing the effects of treatments, they are as follows:

Treatments (Rates per Acre)	Percent Kill		
	Broad Leaves	Grasses	Beets
1. 100 lbs. salt, 100 gallons water, open nozzle #0 orifice, 2nd application same date, open nozzle #00 orifice, 6 " above beets	89	86	2
2. 200 lbs. salt, 100 gallons water, two #00 nozzles lengthwise of row under hood, 6" above beets	90	78	0
3. 180 lbs. salt, 80 gallons water in 6" strip under hood	90	80	0
4. 360 lbs. salt, 160 gallons water, 6" strip	100	97	4
5. 540 lbs salt, 240 gallons water, 6" strips under hood	100	100	18

Soil samples were taken at intervals in order to determine, if any, the residual effects of using salt. The soil is classed as a fine loam with a pH of 7.8 to 8.0 which remained the same throughout these tests. Samples were taken at depths ranging from 0-3 inches and 3 to 6 inches and 6 to 12 inches. Our Associate Agronomist, Mr. J. T. Alexander, who made the soil determinations states, and I quote, "The first samples 0 to 3 inches, 3 to 6 inches, etc., show no measurable increase in the amount of sodium present, either soluble sodium or exchangeable sodium." The per cent exchangeable sodium in these samples ranges from 1.3% to 6.2%, the latter being taken from the plot obtaining the highest rate of application, namely 540 pounds.

HOLLY SUGAR CORPORATION

SOIL SAMPLES FROM SALT SPRAY PLOT - FOUNTAIN, COLORADO

Samples From:	Total salts Milliequivalents per liter		% Soluble sodium		% Exchangeable Sodium	
	First Sampling	Second Sampling	First Sampling	Second Sampling	First Sampling	Second Sampling
Field A	32	52	15.6	36.5	1.3	3.5
Field B	780	58	5.1	12.9	2.0	1.8
Field D	50	70	28.0	28.6	4.5	3.8
Field E	-	51	-	27.4	-	3.0
Field E No.	51	-	37.2	-	6.2	-
Field E So.	80	-	25.0	-	4.0	-
Untreated	50	-	15.0	-	2.0	-
200# TCA	90	-	36.1	-	6.0	-

In addition - 3 treatments of sodium trichloroacetate plus 200 lbs. salt per 100 gallons water were used at the following rates, 50, 100, and 200 lbs. per acre and 3 treatments of ammonium trichloroacetate plus 200 lbs. salt per 100 gallons of water at the same rates of application. Results were as follows:

Treatment	Percent kill		
	Broad Leaves	Grasses	Beets
50 lbs. STCA plus 200 lbs salt plus 100 gals. water per A.	100	85	4
100 lbs. STCA plus " " " " " " water per A.	97	90	11
200 lbs. STCA plus " " " " " " water per A.	100	100	60
50 lbs. ATCA plus " " " " " " water per A.	100	90	0
100 lbs. ATCA plus " " " " " " water per A.	100	92	13
200 lbs. ATCA plus " " " " " " water per A.	100	95	18

As the above materials are not obtainable commercially and the cost has not been determined of these treatments, we are not in a position to advocate the use of this treatment; however, further tests will be made in 1949.

Selective salt spraying in the Saginaw area is becoming more widely practiced by growers in the Eastern area each year. Some growers are purchasing equipment solely for this purpose. This is particularly true of large scale farmers who grow beets on muck land and are forced to recognize the weed problem on this type of soil.

Their work with salt sprays brought forth some interesting facts this year. The following observations were made:

1. Wild mustard was sprayed on two different farms when the mustard was in the two-leaf stage and the beets were emerging from the ground. In both cases we advised the grower to stop spraying because the mustard was not being affected by the salt. Within three days it was evident that the mustard population was considerably lower in the sprayed than in the unsprayed area. Apparently the salt reacted slowly on the mustard. Temperatures were relatively cool and no injury to the beet seedlings was observed.

2. Rough pigweed (Redroot) seems to be completely salt tolerant when in the two-leaf stage, while ragweed is extremely sensitive to salt at this stage of growth. Rough pigweed is readily eradicated when it reaches the four-leaf stage.

3. Wild mustard was sprayed when approximately 6" in height. The single boom carrying one #78 Monarch nozzle over each row was replaced by two booms, (one at front of sprayer, one behind) each carrying one cone-type nozzle with a smaller orifice. All nozzles were located directly over the row. This sprayer set-up applied the same amount of salt solution per acre as the #78 nozzles, but gave a softer spray, smaller droplets, and a more complete coverage of the mustard. The result was a complete kill of mustard even at this advanced stage of growth.

During salt spraying operations on a commercial scale in the Holly Sugar Corporation's territory at Holly, Colorado, experiments were run in which a Western land roller was used in an effort to improve the kill on grasses in sugar beets. It was found, however, that this method was too severe on the beets themselves and the loss incurred in the killing of beets was too great. It is felt that by breaking down the epidermal or waxy surface of the beet, the salt penetrates and, therefore, has a lethal effect.

CHEMICAL WEED CONTROL ON SOYBEANS, OTHER LEGUMES, AND MISCELLANEOUS CROPS

C. R. Swanson

Investigations of weed control methods in legumes and miscellaneous crops were carried on in 1948 at Harrow, Ontario; Urbana, Illinois; Columbus, Ohio; Brookings, S. Dak.; Fargo, N. Dak.; Croton, Ohio; Winnipeg, Man.; South Haven, Mich.; and Lincoln, Nebraska.

Reports are available from six stations on weed control experiments in soybeans with the interest centering on applications of various formulations of 2,4-D, two formulations of trichloroacetic acid, and a dinitro. Experiments on control of weeds in Ladino and red clover is reported from two stations. Pre-emergence applications of several herbicides on peas are reported by two stations. One station made pre-emergence applications of a number of herbicides on sesame, sunflower, safflower, castor beans and perilla.

2,4-D was applied to soybeans at rates ranging from 1/48 to 4 pounds acid equivalent per acre as the sodium salt, amine, isopropyl and butyl esters at a number of stages of growth from the time of emergence to the first flower stage. The ester formulations had the most severe effect on soybeans and in all cases where there was satisfactory weed control, the injury to soybeans was excessive. Grass weeds were not controlled and outgrew the stunted soybeans. Applications of 2,4-D at time of emergence had a less depressing effect on soybeans than later spraying. On the basis of one report on post-emergence trials the cotyledon and flowering stages appeared to be the most resistant to 2,4-D. Another study indicated that application of $\frac{1}{4}$ pound of 2,4-D acid when the soybeans were 6 to 8 inches tall did not decrease the yield of the varieties Lincoln, Manchukota and Bavender Special, but did decrease the yields of Capital, Hawkeye, Richland, Ottawa Mandarin, Flambeau and Earlyana. Yields were reduced for all varieties at $\frac{1}{4}$ pound applications. Rates of application up to 4 pounds per acre applied at time emergence reduced stands excessively and allowed grass weeds to grow abundantly. Generally, maturity was delayed from one to two weeks.

Ester and sodium salt formulations of 2,4-D were applied to second year red clover in February, March, April and June in an attempt to eliminate narrow leaf plantain. Any rate that killed plantain was excessively injurious to red clover. At the same station one pound of 2,4-D acid per acre as the amine applied to Ladino clover curled the leaves initially but the clover grew out of it and appleared normal. In another case a field with a thick stand of Ladino clover and a light stand of medium red clover infested with Canada thistle, broad-leaf plantain and curled dock was sprayed in May with $\frac{1}{4}$ pound 2,4-D acid as the butyl ester. Besides killing the plantain, dock and thistle, the red clover was eliminated. Ladino clover was set back in this case but recovered and set seed well.

Butyl ester and sodium salt formulations of 2,4-D were applied to Little Marvel garden peas two days after planting and just before emergence of the crop. On a pod weight basis the yield from plots sprayed with $\frac{1}{2}$ pound and 1 pound 2,4-D was reduced significantly. This reduction in yield was not so severe from applications made just before emergence. Reductions in yield were attributed to reduced emergence and stand rather than to plant distortion. Early recovery was noted for peas distorted by 2,4-D.

Pre-emergence applications of LFN No. 472 at 1 and 2 pounds and an unspecified formulation of 2,4-D at $\frac{1}{2}$, 1 and 2 lbs. were made to sesame, safflower, castor beans, perilla and sunflower two days after planting. LFN No. 472 at 1 pound showed good weed control and did not affect sesame, castor beans, perilla or sunflower. No weed control or damage to crops was noted with application of $\frac{1}{2}$ pound 2,4-D. 2,4-D showed good weed control at 1 and 2 pounds but affected all crops to some extent.

Rates of application of ammonium and sodium salts of trichloroacetic acid on soybeans ranged from 5 to 100 pounds acid equivalent per acre sprayed at the time of emergence, the 6 to 8 inch height stage and the 24 inch height stage. The action of ammonium TCA on soybeans sprayed at emergence was quite severe. At 25 pounds per acre the cotyledons and first leaves were wrinkled and brittle. At the 50 pound application this effect was somewhat greater with a noticeable reduction in stand and at 100 pounds the first

true leaves were greatly dwarfed, yellowed and brittle. Grass weeds were well controlled at all of these rates. In another study in which the ammonium salt of TCA was applied to 6 to 8 inch tall soybeans at rates of 6 and 16 pounds acid equivalent per acre, grass weeds were not controlled and maturity of the soybeans was delayed more than two weeks. No particular varietal resistance to TCA was noted and yields were decreased to a highly significant degree at both rates of application. Soybean plots infested with grass weeds were sprayed when 24 inches tall with 5, 10 and 50 pounds of TCA. Only the 50 pound applications controlled grass weeds, while all rates affected soybeans severely. No pods were formed at 10 and 50 pound application and soybeans treated with 5 pounds produced unfilled pods for the most part. Grass weeds seemed to be controlled only with applications in excess of 25 pounds per acre.

Sodium and ammonium TCA applied at 25 and 50 pounds per acre as a pre-emergence treatment on sesame, safflower, castor beans, perilla and sunflower did not control weeds but affected these crops.

Only one report is available on treatment of soybeans with a dinitro. Sinox W was applied at the time of emergence at $\frac{1}{2}$, 1 and 2 pounds per acre with good weed control at all rates. Reduction of stand occurred to some extent at the 1 pound rate and a 50% stand was obtained at the 2 pound rate. No yield data were obtained. In another case a dinitro controlled small-seeded weeds when applied pre-emergence to large-seeded crops including corn, peas, various beans, cucurbits and sunflower without injury to the crops. Surface moisture was necessary for optimum action. Dinitro applied to red clover did not prevent seed production of buckhorn without severely affecting the clover. Weeds in sesame, safflower, castor beans, perilla and sunflower were controlled by pre-emergence treatment at 1 and 2 pounds per acre of Sinox General but the crops were damaged.

Sodium pentachlorophenate showed good weed control and did not damage castor beans, sunflower, and perilla at 4 pounds per acre but the latter crop was damaged at 12 pounds pre-emergence treatment. Other crops which were not injured by PCP or its sodium salt with good weed control on pre-emergence treatments were corn, peas, various beans, cucurbits, and sunflower.

Isopropyl-N-phenyl carbamate (IPC) applied to oil seed crops such as sesame, etc., at $7\frac{1}{2}$ and 15 pounds per acre as a pre-emergence treatment gave fair weed control at the higher rate. No action on the crops was indicated. Diesel oil applied at 50 and 80 gallons per acre to the same crops at the same time gave no weed control and affected all crops.

WEED CONTROL IN POTATOES BY THE USE OF VARIOUS CHEMICALS

Glenn Viehmeyer, Univ. of Nebr. Substation, North Platte, Nebr.

In summarizing regional results of various weed control practices in potatoes, it would seem advisable that attention be drawn to the limited number of reports received, and to the omission of certain pertinent data

from those reports. These omissions are:

1. Failure to give soil type.
2. Failure to name variety of potato in the test.
3. Failure to give dosage used in treating.

This is mentioned, not as a criticism of cooperators reporting but rather to draw attention to the fact that without such information, conclusions drawn, may be wide of the mark in certain respects.

Most cooperators reporting on potatoes failed to mention soil type, and yet, soil type may be highly important where the pre-emergence type of weed control is attempted. This seems particularly true where a herbicide such as 2,4-D is used. Soils vary in absorption capacity and it may be possible that injury to germinating crop seed and emerging seedlings is correlated to absorption capacities of the soil. Such correlation between soil type and plant response has been reported for a number of crops and may prove to be important in the treatment of potatoes.

There is some indication of varietal response to 2,4-D in the reports, but no conclusion regarding the importance of such response is possible from the limited information offered. However, investigations with other crops indicate that varietal differences in tolerance are very important at times.

Dosage applied is, of course, always important, and omission of such information detracts a great deal from the value of an abstract.

Abstracts submitted seem to fall into two rather clear-cut classifications, pre-emergence and post-emergence treatments. These two types of treatment are best considered separately.

Pre-emergence treatments

With the exception of a slight stem distortion, reported by Anderson and Mantell of Manitoba, no report or morphological effect of 2,4-D pre-emergence treatment is made where such treatment was applied five or more days ahead of the potatoes breaking the soil. On the other hand, Wilson, Bruner, and Hall of Ohio, report that treatment applied as the first plants had emerged and the rest of the stand was presumably just below the surface resulted in severe deformation with no normal foliage being produced for six weeks.

Weed control was least effective if application was made at time of planting the potatoes and was most effective where a number of days had elapsed following planting, allowing weed seed brought to the surface in the planting operation to begin germination. The reports indicate that pre-emergence treatment should be delayed as long as possible but must be made before the potato plant is at or near the surface of the soil.

It seems that 2,4-D may hold considerable promise as a herbicide for pre-emergence weed control in potatoes.

Wilson, Bruner and Hall also report that pentachlorophenate and 2,4,dinitro secondary butyl phenol gave excellent weed control when applied as the first

potatoes were breaking the soil surface. Some burning occurred to plants above ground but this was apparently temporary in nature and recovery was rapid.

Sinox is reported as giving excellent weed control at 2 lbs., good control at 1 lb., and fair control at 1/2 lb. per acre.

Under favorable conditions, these chemicals have given as high as six weeks control of weeds. In other cases control has been unsatisfactory.

A single report of ammonium trichloroacetate (TCA) indicates that that herbicide is very effective in controlling grassy weeds. Applications of 100, 50, and 25 pounds controlled grass at all dosages. Unfortunately, the compound is also highly toxic to potatoes at the above dosages.

Post-emergence treatments

Reports on five varieties of potatoes, Chippewa, Cobbler, Katahdin, Rural Russet, and Triumph, indicates all varieties are deformed by post-emergence 2,4-D treatments, with Rural Russet showing greatest response. Potatoes are most seriously affected if treated during the rapid growth period at and following emergence. Tolerance increases with age, with mature plants showing few gross morphological responses.

No cooperator reports statistically significant reduction in yield of tubers following 2,4-D treatments.

Sodium pentachlorophenate and the dinitros have been used at time of potato emergence. Considerable burning of plant parts receiving direct application of these herbicides was noted. Such injury was temporary in nature and recovery rapid.

In summing up, investigations have not been extensive enough or carried on over a long enough period to justify recommendations for or against the use of herbicides in potatoes. 2,4-D, the dinitros and pentachlorophenols all seem to have promise for both pre-/and post-emergence weed control. More refined experiments, designed to measure effect of soil type, varietal tolerance, dosage, and stage of growth on yield and keeping quality seem advisable.

From the present very limited information on the subject, it seems probable that chemical weed control will have a place in potato production.

Wednesday Evening, December 8

Leland Hotel Ballroom

SECTION II -- SYMPOSIUM ON RESEARCH IN THE ERADICATION OF WOODY PLANTS

L. W. Melander, Chairman

The meeting was called to order by the Chairman, L. W. Melander, at 8:00 P.M. There were about 200 people in attendance.

The Chairman outlined briefly the purpose of the symposium and reviewed some of the problems confronting workers in the field of woody plant eradication. Stress was placed on the need for more information on methods of application that would provide a more efficient "kill".

While there was no restriction on the subjects covered, the discussions were concerned principally with penetration, absorption, and translocation of herbicides, although during the two-hour session many phases of the problem of eradicating woody plants were covered.

The following committee was appointed to take notes and to submit a brief summary of the topics that were discussed: Harry M. Elwell, Chairman, R. H. Beatty, J. W. Zahnley, J. A. Krober, and F. A. Ashbaugh.

The following report was submitted by this committee:

Suggestions for Future Work on Problems Dealing with the Control of Undesirable Herbaceous and Woody Plants

It was the consensus of opinion that basic physiologic studies relative to the intake and movement of 2,4-D and related herbicidal chemicals should be continued. There were several reports on work that had been accomplished during the year and general agreement that the following subjects should have further investigation:

1. The effect of various ester, amine, and salt formulations. In general, the group felt that as water emulsions the esters are most effective.

2. Are better results obtained with low concentrations in water emulsions with heavier volume applications than high concentrations and lower rates of application, within limits?

3. Are the oils that give a minimum burning, such as low aromatic minerals or vegetable oils, proving satisfactory as carriers and penetrants in low-volume, high-concentration applications?

4. Is it true that oils might impede the movement of herbicides through the plant?

5. Further study of better technique, such as radio-active tracer tests, to furnish further information on the movement of chemicals in the plant.

6. Cuticle- and cambium-layer studies, to determine when their condition is ideal for the maximum absorption of a herbicide. As this is determined, investigation should be made to determine how to bring about this ideal condition or how to adjust the spray solutions to offset the conditions which impede the absorption of the chemical.

7. Discover the substances in resistant plants which inactivate the herbicide.

8. Establish research to determine the following: (a) the most desirable and effective carriers and concentration; (b) various types of weather which might affect results; (c) the part of the plant to be treated for the most effective results; (d) the amount of solution needed.

9. There was information presented to show that stump-application would control resprouting. More study should be given to this technique, principally to the concentrations to be used, carriers, seasons of the year when applications are most effective, etc.

10. The effect of emulsifiers, spreaders, and stickers on the "kill" when water-soluble chemicals are used. The group was of the opinion that these aided in the effectiveness of the "kill".

11. Would the use of acid forms with co-soluents in oil reduce the harmful effect to adjacent plants due to volatility?

12. What is the ideal particle-size needed to obtain the maximum contact with the spray solution and thus reduce the amount of drift to adjacent groups?

13. Do combinations of the herbicides give a more desirable reaction on a wider range of plants? Combining 2,4-D and 2,4,5-T appears promising for killing woody plants.

14. Better biological test methods to speed up the evaluation of the effect of herbicidal chemicals. The injection method appears to be very promising.

15. The need for studies of any sites on which large-scale spraying or clearing might be considered, to determine its potentiality for the production of a rapid cover of erosion-resistant grasses. The group was of the opinion that the study should be made principally because woodland pastures and range land covered with undesirable herbaceous and woody plants are generally located on soils that will erode readily by wind or water. It was suggested that educational work should be done to promote the proper management of such cleared land.

Respectfully submitted by the Committee.

Harry M. Elwell, Chairman.

Thursday morning, December 9

Centennial Auditorium

GENERAL SESSION
T. F. Yost, Chairman

PERENNIAL AND ANNUAL WEEDS
A. H. Larson and George Knowles, in charge

A SURVEY OF A SEASON OF 2,4-D SPRAYING

Len Weigand, Manager, Associated Dealers Supply, Willmar, Minnesota

The following tabulations are based on questionnaires mailed to 553 farmers in seven North Central States. The names were picked at random from lists furnished by our dealers. These results are based on the first 100 questionnaires returned.

Answers to our questionnaires indicate that chemical weed spraying has been highly satisfactory in this area, and a general increase in the use of chemicals may be expected in 1949. Our answers also indicate that a considerable greater acerage of corn will be sprayed in the North Central States.

In answer to our question, "In what stage of growth were weeds when sprayed? (Small, Medium, Tall)", tabulation showed best results when weeds were small.

Regarding flax, the trend seems to definitely be toward the use of 2,4-D and we noted that many farmers had sprayed varieties of flax considered to be susceptible to 2,4-D with results they considered good and with no apparent damage. In many cases they mentioned flax was retarded or had temporarily turned brown but that it had made a good comeback.

The majority of the farmers who answered questionnaires used approximately 10 gallons of water per acre with 2,4-D and in answer to our question, "Should more or less water be used" they almost unanimously agreed 10 gallons was about correct. Several using 5 gallons per acre stated that more water would have been better as they experienced problem of drift.

Nine percent experienced difficulty in mixing chemical with water - primarily where water was hard and cold. There seemed to be a definite difference in brand of chemical, some mixed more readily than others. In most cases farmers mentioned when temperature increases and water is warm, they have less trouble.

Although 48% of the farmers reporting stated they had done some custom work, the majority said they would discontinue this. Indicating that weed spraying will become an individual farm practice.

A number of farmers expressed the opinion that a stronger mixture of 2,4-D might be used on small grains, especially wheat and oats.

The following figures are based on the first 100 questionnaires returned:

Total number of acres sprayed - 20,877 acres.
Average acres per farm sprayed - 208.77 acres.

48% reported they had done custom spraying

90% sprayed grains
48% sprayed corn
18% sprayed legumes or flax

59% reported increased yields
28% reported no increase
13% reported no opinion

97% reported no indication of damage
3% reported slight damage

9% reported trouble in mixing chemicals with water

83% reported they would do more spraying in 1949
17% reported they would do about the same

In answer to our question "In what way could equipment be improved?", on the whole the complaints on equipment were of a minor number considering the inadequacy of the 1948 sprayers. The following suggestions were made: Better filters to avoid clogged nozzles; stronger booms made to adjust for greater heights, i.e., for spraying corn, etc.; better pumps with positive drive to eliminate slippage; booms to be made of materials non-corrosive to help eliminate clogged nozzles; boom to be made so they can be folded to go through gates, etc., also to be adjustable for fence row spraying; tanks with brackets to fit tractors to avoid extra tracks in fields.

We are of the opinion that pumps used for sprayers should be of adequate capacity. Pumps that are run beyond the R.P.M. recommended by manufacturer will naturally have a shorter life. We further believe that pumps should be capable of handling insecticide and that they have by-pass for agitation of material. We have found in our experience that many farmers measure the chemical used quite carefully but do not measure the water used, i.e., a farmer using a 100 gallon tank after making his first application, measures the amount of chemical to be used in 100 gallons of water and then fills the remainder of the tank with water. In the majority of cases, the tanks are not entirely emptied, there may be 6 to 10 gallons of mixed solution left in bottom of tank. Actually then, he is putting only 90 or 94 gallons of water in his tank and theoretically his solution keeps getting stronger each round.

Some unusual comments contained in questionnaire submitted by farmers, which are typical, are noted below:

J. W. Donnay, Watkins, Minnesota - Weed kill was good. Sprayed thistles in one small field of corn when corn was not over 4 inches high. Completed thistle control and no visible corn damage there, but large corn tends to droop for awhile after spraying.

Jess Maus, Osakis, Minnesota - I sprayed new seeding of alfalfa that was infested with thistles and mustard and cut the dose to 1/2 pint of 2,4-D amine per acre. It killed every thistle and mustard in the field but did not hurt the alfalfa one bit.

Ernest Risch, Elkton, South Dakota - I sprayed alfalfa after I cut the first crop for sow thistle with no ill effects. Get some spray that kills pigeon grass and not the corn and you will have something for us in these parts.

Wayne F. Sandberg, Mohall, North Dakota - Most of our spraying was to control volunteer sunflowers, row cropped the year before. We used 1/2 pint per acre and found it to be very satisfactory. There was infestations of Sow and Canadian thistles. These spots were given a double dose and in places found to be entirely killed, other places were stopped from seeding.

Our experience this year told us that time of spraying is just as important as any other factor in spraying. In fact, the importance of time of spraying cannot be over stressed. Volunteer clover was not affected by spraying, while at the same time mustard, Frenchweed and ragweed were very noticeably retarded. However, if we had sprayed three weeks earlier the spraying would have been again as effective.

We found dead grasshoppers clinging to the stems of sunflowers and sow thistles, sometimes as many as a dozen in one small branch. They could not be found clinging to other plants. We wonder if the condition of the plant after 2,4-D has been sprayed on it does this.

We have not tried to draw any conclusions as this survey was merely intended as a report on the farmers experience as well as suggestions in controlling weeds with chemicals.

ANNUAL WEED CONTROL IN THE HARD WINTER WHEAT BELT*

W. M. Phillips

In the relatively few years since 2,4-D was discovered it has become generally established and is now an important and valuable tool in controlling annual weeds in wheat in the Southern Great Plains region. I would like to discuss some of the phases of annual weed control in their relation to crop production.

Information upon which these remarks are based was gained primarily from three experiments conducted at the Fort Hays Experiment Station during 1948. The first was a rate-and-date-of-application test of 2,4-D on winter wheat. While this experiment was designed primarily to test the effect of 2,4-D on wheat, it afforded an excellent chance to study the reaction of various annual weeds sprayed at four different stages of growth. A second experiment

*Contribution of Bureau of Plant Industry, Soils and Agricultural Engineering, Division of Cereal Crops and Diseases, Hays, Kans.

involving thirteen different spray treatments applied with an airplane gave valuable information concerning the type of carrier and the volume necessary for controlling weeds with airplane spraying. The third experiment, conducted in cooperation with the Dry Land Agriculture Project tested the value of 2,4-D and dinitro compounds as substitutes for one or more cultivations in a summer fallow program. In addition to these experiments, extensive observations were made on commercial wheat and sorghum fields which were sprayed with 2,4-D. In these it was possible to study the reaction of weeds at almost every conceivable stage of growth, from emergence to virtual maturity.

It is estimated that at least five hundred thousand acres of winter wheat in Kansas were sprayed in 1948 to control annual weeds. To those of you from areas where the spraying program has been in progress for two or three years this acreage probably does not seem large. It should be pointed out, however, that prior to 1948 practically no 2,4-D had been used in selective spraying of crops in the hard winter wheat belt. Without going into the details of this spraying program may I say that the results were generally satisfactory and weed control was excellent especially in those fields that were sprayed while the weeds were relatively small.

The wheat spraying experiment involved, as I have said, four different stages of growth. Applications of a sodium salt and an ester were made at from three to five rates on each date. From observations made during 1948, I feel that in the past too little emphasis has been placed on the stage of development of the weed when sprayed and too much significance attached to the reaction of any particular species. Stage of growth seems to me to be of prime importance in the control of annual weeds. In general, control of all species became less effective as they grew larger and approached maturity. Some weeds which were rather easily killed even at low dosages a short time after they emerged became quite resistant at later stages of development.

No attempt was made to study the effect of various volumes of spray application in the experiments conducted with ground spraying equipment. In the previously mentioned airplane spraying experiment the methyl, butyl and isopropyl esters were applied at 1/4 and 1/3 pound per acre in a diesel fuel carrier. One gallon per acre of the solution was applied. The isopropyl ester was applied at 1/4 and 1/3 pound per acre in 2 gallons of water. An amine was applied in 5 gallons of water at the rates of 1/2 and 2/3 pound per acre and 1/2 pound of amine was applied in 2 gallons of water. There was little difference between the three types of ester applied in oil. In every case the 1/3 pound gave somewhat better control of weeds although the 1/4 pound was, in most cases, quite satisfactory. The isopropyl ester in 2 gallons of water and the 1/2 pound amine in 2 gallons of water gave rather poor weed control. Both the 1/2 and 2/3 pound of amine in 5 gallons of water were quite satisfactory but did not give as complete kill of weeds as did the esters in oil. Results from this experiment seemed to indicate that when applied by airplane under Kansas conditions, oil is a very efficient carrier of 2,4-D, and if water is used the volume should approach 5 gallons per acre.

I should like now to spend a few minutes discussing some reactions of a few species of annual weeds. Of course in Kansas, we never have a shortage of sunflowers (Helianthus annuus) and in western Kansas the Russian thistle (Salsola kali var tenuifolia) and Kochia (Kochia scoparia) are notorious.

In addition to these rough pigweed (Amaranthus retroflexus), lambsquarters (Chenapodium album) and horseweed (Erigeron canadensis) are prevalent. None of these are ordinarily classified as highly resistant to 2,4-D. Russian thistle and horseweed have often been found listed in the intermediate class of susceptibility. Lambsquarters has been classed as only moderately susceptible. 1948 results indicate that all of these weeds are quite readily controlled when they are small, 6 inches or less high, even with rather low rates of application. Wheat plots sprayed with 1/4 pound of ester April 26, 1948, were almost entirely free from the above mentioned weeds when the plots were harvested. In contrast, plots sprayed May 27, 1948, with 1/4 pound of ester still had more than 80 percent of the original stand of weeds. This later application did stunt most of the weeds and prevented seed production in many cases.

The sunflower has been regarded as rather highly susceptible to 2,4-D. However, it was noted that in a number of cases 1/3 of a pound of ester failed to completely kill sunflowers even though they were in a rapid growing condition and about 1 foot high. The terminal growing point appeared to die, but in a short time new sprouts emerged from immediately below this point and continued to grow normally. Thus in place of one sunflower stalk there were five or six.

Rough pigweed, when soil moisture is ample for good growth, seems to be readily killed with 1/3 pound of ester at almost any stage of growth until it has begun to set seed.

This year lambsquarters in Kansas wheat fields was a good indicator plant and an excellent salesman for spraying with 2,4-D. Many wheat fields were badly infested with this weed and when sprayed when 6 to 8 inches high or less they reacted quite rapidly to 2,4-D. Excellent kills were obtained in nearly every instance in which this weed was sprayed. Kochia reacted quite similarly.

Russian thistle and horseweed are, as previously mentioned, rather easily killed when small but as they approach the flowering and seed setting stage, they become quite tolerant to 2,4-D. One pound of ester per acre at these stages failed to give complete eradication but when sprayed before seed was set, it effectively prevented seed production. Notes taken on the chemical summer fallow experiment indicate that horseweed in the later stages of growth is somewhat easier to control with dinitro products than are most other weeds in comparable stages of growth.

In 1947 excellent weed control was achieved on the chemical fallow experiment with both the 2,4-D and dinitro compounds. In 1948, however, for some unexplainable reason the first application of the chemicals failed to give satisfactory weed control. Later applications were made but the weeds had increased in size and were approching maturity so that from the standpoint of weed eradication the treatments were not at all successful. The dinitro applications have been only moderately successful in eradicating annual grasses and volunteer grain. 2,4-D is, of course, ineffective on these grasses.

Throughout the discussion it is noted that in nearly every case the ester is used as an index of the susceptibility of the various weed species. No amine was used in these experiments except as mentioned in the airplane spraying experiment. The rates of sodium salt required to give comparable weed control were at least twice as high as for the ester formulations. This is entirely in agreement with past findings at the Hays station.

Since 1948 was the first year that 2,4-D has been widely used on a commercial scale for controlling annual weeds in crops in the winter wheat area, we should perhaps advance with caution. It is recognized that in general one year's results may not give too sound a basis for making recommendations. However, we feel that if some discretion is used, 2,4-D can be of great value in controlling annual weeds in winter wheat. While it is true that in most years there is no serious weed problem in winter wheat, this past season was a striking exception. If that exception should reoccur, it is nearly certain that the number of acres treated will far surpass the 1948 total. A combination of excellent weed control and little or no indication of chemical damage to their wheat crop has sold thousands of farmers on the use of 2,4-D.

THE USE OF 2,4-D IN THE CONTROL OF PERENNIAL HERBACEOUS WEEDS

G. Knowles, Central Experimental Farms, Ottawa, Canada

The committee on perennial herbaceous weed control with 2,4-D has analyzed and summarized the results obtained from co-operators in this experiment.

The work of analyzing and summarizing these data was divided between the members of this committee as follows:

L. A. Derscheid	Field bindweed
A. L. Bakke	Canada thistle
H. E. Wood	Perennial sow thistle
J. W. Zahnley	White top or Hoary cress
T. K. Pavlychenko	Leafy spurge
G. Knowles	Russian knapweed
G. Knowles	Other herbacious perennials

The following is a digest of the summaries prepared by the above mentioned members of this committee.

Field Bindweed

One outstanding conclusion that can be drawn is that 2,4-D seldom eradicates field bindweed. Retreatments keep it under control but do not completely kill it. All investigators report that 90 to 95 percent control is not uncommon.

There is considerable difference of opinion as to the stage of growth at which field bindweed is most susceptible to 2,4-D. Some got good results from applications on fall growth, others favoured the bud stage, others again got better results from applications when the plant was in full bloom.

Conditions which produce rapid growth at time of treatment is possibly the important factor in achieving good results.

There appears to be no great difference in the effectiveness of the various formulations on bindweed but all investigators agree that less 2,4-D is needed to control this weed than was originally thought necessary. Under adverse growing conditions rates of more than a pound of 2,4-D acid per acre gave better results than amounts of less than a pound and the ester seems more effective under adverse conditions.

Promising results have been reported from the use of 2,4-D in conjunction with cultural and cropping methods.

Canada Thistle

Canada thistle often shows marked tolerance to 2,4-D treatments. In some localities it appears to be more resistant than in others. Two treatments each year for two years, in some instances, have not eradicated this weed.

The early growth stages, up to first flowering, seem to be the desirable time to apply 2,4-D for Canada thistle control.

While several co-operators reported better results from the use of ester, there were just as many who found no marked difference in formulation. 2,4,5-T was no better than 2,4-D.

The degree of effectiveness is pretty much in direct relationship to the amount of 2,4-D applied, but one pound of acid per acre seems to be sufficient when treating Canada thistle that is not in a susceptible crop.

Very promising results have been reported from the use of low amounts of 2,4-D to control Canada thistle in growing crops such as corn and grain. These amounts should vary according to the tolerance of the crop.

Perennial Sow Thistle

The consensus of opinion is that one application of 2,4-D is not enough to kill perennial sow thistle. The greater the amount of 2,4-D applied the greater is the percentage kill. This is true for amounts up to 2 pounds acid per acre. There seems to be no advantage in using more than that amount.

The majority of co-operators favoured esters, but some favoured the amine formulation. The first bud or from bud to early flowering stage appears to be the best time to apply 2,4-D on perennial sow thistle.

One report says that in a grain crop this weed was controlled to a point where it did not produce seed and gave very little trouble at harvest by applications of from 1/4 to 1/2 pound 2,4-D acid per acre applied at the early bud stage.

In conjunction with 2,4-D competition from agressive grasses hastens sow thistle eradication.

White Top or Hoary Cress

The indications are that it may take three years of repeated applications of 2,4-D to eradicate hoary cress.

The esters appear to be more effective in most cases than are the amines and sodium salt and 2 pounds acid per acre seems to be the minimum amount to use for consistently good results.

Treatment in the bud to full bloom and in the fall rosette stages is the most effective.

Established grass in conjunction with 2,4-D seems to aid in the control of this weed.

Leafy Spurge

All experimenters agree that leafy spurge is difficult to eradicate. There is pretty general agreement that repeated treatments using small amounts of 2,4-D offer greater promise than fewer treatments with large dosages.

The presence of competitive grass is an aid to 2,4-D in controlling this weed. There is some indication that cultivation prior to treatment renders 2,4-D more effective when applied on the regrowth. One investigation found that a single treatment of young leafy spurge in a grain crop with only 4 ounces per acre of 2,4-D acid stunted this weed and kept it from going to seed.

All treatments at rates of 1 pound or more per acre regardless of the formation destroyed the top growth and prevented seed formation.

2,4,5-T does not offer any advantage over the 2,4-D formulations. Sometimes it seemed less effective.

Russian Knapweed

Only one fragmentary report was received on Russian knapweed. It states that an infestation of this weed has received repeated treatments with 2,4-D since 1946. The area is now overrun with grass and annual weeds with an average of one Russian knapweed in 1.5 square yards still remaining.

Other Perennials

The need for information on the effect of 2,4-D on a long list of perennial weeds other than the above mentioned is recognized. This year a check list of approximately 100 perennial weeds was sent to each co-operator and with it a form in which to report the amount of 2,4-D per acre required to kill the top growth and the number of applications required to kill the root growth of each weed.

The number of replies to this request has been rather disappointing but it is realized there is a limit to the amount of work co-operators can undertake. However, a beginning has been made on a classification of perennial

weeds based on their susceptibility to 2,4-D which when completed should be a valuable reference to all interested in 2,4-D.

It should be pointed out that the original form for reporting this information has been changed somewhat in the interest of uniformity with the form of reporting similar information on annuals and woody plants.

EDUCATIONAL AND ACTION PROGRAMS
W. L. Klatt and E. P. Sylwester in charge

WHAT DO WE NEED IN HERBICIDE LAWS?

Warden L. Noe, Kansas

Modern technological advancement in the field of agricultural chemicals, and the equipment used to apply such materials, has become almost a miracle in American agriculture and is certainly a great tribute to our free enterprise system of scientific research.

To develop such a miracle, however, the American methods of farming have had to undergo extensive changes, in operating techniques, and these changes probably will grow more pronounced within the next few years. In developing this thought a little further it is certainly obvious that legislation regarding the agricultural industry should also undergo major revisions and modernization if laws are to prove a benefit and not a blight to the agriculturalists of this nation.

It is a pleasure to report that progressive legislatures and political leaders are prepared to make such changes as are necessary. Even as we are meeting here in Springfield there are many states throughout our own North Central conference area and throughout the nation that have either already enacted revised herbicidal laws or are actively considering such legislation.

As with any new thought development or major change in methods of operation, regardless of the field where they happen to occur, all alterations are not an advantage.

In the field of herbicides we find that in some cases the laws that have been passed or are being urged upon the state legislatures are far too strict in their requirements and may prove in some states to be of more harm than benefit.

Other states which have been too lax in passing proper and needed legislation, may suffer serious consequences from such neglect and carelessness.

Speaking before such a group as this I know that I do not have to emphasize the seriousness of the problem facing us. You men realize that the dramatic results obtained with new agricultural chemicals, when properly used, are possible only because the chemicals are powerful and thusly when improperly used can produce disastrous results.

Equally, you attending this meeting today, realize that in spite of these dangers, the advantages of these new weapons in the agricultural war of production, far outweigh the disadvantages they have.

Fundamentally then, we come to the problem which faced the committee on Herbicide Laws in preparing suggested bills. The committee realized there was a definite need for laws regarding these agricultural chemicals, and more recently with respect to the equipment used in applying such materials.

On the other side of the ledger, however, was the realization that the requirements should be such as to avoid too much detail, thereby making them difficult if not impossible to enforce. Equally prohibitions could be so strict as to deprive the public of the benefit and ease of application of these potential boons to agriculture.

Another feature that the committee took into consideration was the fact that many states already have agricultural chemical (economic poisons) legislation and that the bill now recommended by this committee is of such a form that it can be used in revising or strengthening such existing legislation.

Before discussing the proposed bill that the committee will suggest as basis for legislation for control of equipment used in applying herbicides, you might be interested in knowing that although this work is considered new, actually the problem of spraying crops with air and ground machinery is an old one. There have been cases before the courts where damage resulted to the susceptible crops, livestock or bees near the locale where the material was used.

As an example of such litigation, a case came before the courts in Arizona back in 1933. (S. A. Gerrard Co., Inc., v Fricker, 42 Ariz. 503, 27 Pac (2d) 678). In this particular litigation a farmer had contracted to have his lettuce dusted by airplane to rid it of worms. The dust drifted over an apairy joining the lettuce field, killing many of the bees. In the ensuing trial the farmer was found guilty of negligence and was required to pay for the destruction of the bee colonies. This case, aside from being interesting because of its early date, is important in that the court clearly pointed out that the farmer, contracting to have a dangerous piece of work done by another, cannot escape responsibility by claiming the damage resulted from the negligence of the person under contract. This principle has been of importance in legislation that has been considered by several of the states. It is a feature of the bill suggested for control of herbicide dispersing equipment.

It is hoped by the committee that the suggested bill may serve as a useful guide to those states planning to change existing agricultural chemical legislation and to those who undertake to create new laws to meet these new conditions. It is easy to realize that to have somewhat uniform legislation is an advantage to all concerned, whether they are chemical producers, equipment manufacturers, commercial operators of dispersing equipment, the farmer, or other persons who utilize these products and facilities. Not only would favorable legislation greatly speed the adoption of these modern farming practices but equally it would mean a reduction, we believe, in the over-all administrative cost.

While my remarks are personal observations, I shall emphasize some particular parts of the suggested bills that are important enough to merit special consideration by this group.

The committee felt that there was need of legislation supplementing that contained in agricultural chemical, (economic poison) laws enacted after the pattern we recommended in 1946. The use of some dusts on agricultural crops are definitely declining in popularity. With this thought in mind some states may wish to prohibit dusting of crops entirely, or at least as far as the use of 2,4-D is concerned.

We have to constantly keep in mind that the new chemicals now on the market are far more effective than the first products developed for agricultural uses. They are more powerful than anything yet developed. They must be treated with respect and with caution if both the greatest benefit and greatest protection is to be realized. We are well aware of the fact that the day, when every farmer or user of agricultural chemicals could be well informed about the dangers and methods of use of each chemical, has passed. With the great increase in the kind and complexity of these materials it has become paramount that experts in each field be employed or made available to supply consumers, the most valuable and up to date information possible. The role of regulating agencies and educational institutions has greatly increased with the advent of this new chemical farming science.

The fundamental conclusions reached by the committee on Herbicide Laws of interest and worthy of presentation at this time may be generalized as follows:

(1) that the agricultural chemical law should be amended to require more complete labeling of herbicides;

(2) that it is desirable for the states with agricultural chemical (economic poisons) laws, to supplement such laws by the enactment of further legislation requiring the regulation of operators of airplanes and ground equipment who disperse 2,4-D sprays or dusts, and other herbicides;

(3) that each legislative body be requested to give special consideration to the problem of the complexity of any agricultural chemical (economic poisons) law enactment. Such legislation must be workable from an administrative aspect, and must minimize the details for such regulation. Equally the law should be of such strength as to protect the public but not so prohibitive as to seriously deter the broad usage of these agricultural benefactors.

It seems desirable to have a requirement for registration of operators of aircraft and ground machinery for dispersing of herbicides. This will appear in the committee report and we shall not consider it in detail at this time. We do offer these comments:

A particular feature of the proposed bill that should be given careful consideration is the definition of terms. The committee believed this was particularly important. Far too many terms lack definite, uniform meaning between states at the present time. Illustrating the necessity of uniform definitions we might consider the difference in label requirements between states for some agricultural chemicals. In most states, before being allowed to regis-

ter an agricultural chemical the manufacturer must have certain facts on the label. Unfortunately, due primarily to faulty definition of terms, a label that may meet one state's requirements may have to be changed to conform with another state's regulations. The federal law has helped, however, to close this "gap".

In any law that is proposed for a particular state based on this suggested act there probably will be several sectional considerations to be added or deleted. For example, North Carolina passed a bill during its last legislature modeled after the federal act. They made several sectional changes in definitions alone. Among the changes they adopted was inclusion of the words "bacteria", "plant diseases", and "nematodes and other worms". Each region has special problems and will modify this proposed bill to conform to their needs. The proposal for control of equipment used for dispersal of sprays and dusts has been limited in its scope to herbicides, as the committee felt that this field was out in the lead. The insecticide, pest control and similar fields could be added later without present objections from these groups being a deterring factor in obtaining this legislation at the earliest possible time. In view of the fact that herbicide usage is expanding at tremendous rates, we feel that the way should be cleared for immediate enactment of laws for regulation of use of dispersing machinery and equipment used in applying herbicides. Consideration at this particular time of products other than herbicides can well be deferred.

Comments and recommended changes from those in attendance at this meeting are welcomed. At best this bill can only be a pattern, or outline for each state legislature to follow in drafting their individual control laws.

Several other sections of this bill are of major concern to anyone studying possible requirements for registration of operators who disperse herbicides. Number one perhaps is the fact that the committee included airplanes, ground rigs and all machinery used in dispersing herbicides. Much of the demand for legislation of this type has been graphically created from difficulties arising from airplane applications of herbicides. Though less dramatic, several serious damage claims have resulted from the application of herbicides with ground equipment. It can be safely stated that most herbicides of today are dangerous enough to necessitate proper controls for application regardless of equipment used to disperse such material.

To facilitate office administration of this type of legislation the committee has suggested that each registrant under the law list the place where he has been operating within seven days following each week of work. A model type of report would include the location of the area treated, the name of the landowner or employer, and the kind of product and the amount per acre of the herbicide used. This would be especially helpful should any litigation result from application of the herbicide used. The registrant, if a nonresident, is also required to give the name of a resident agent who would accept service of summons, in event a suit is filed for any damage or other claim. The registrant is also required to submit a surety bond to establish financial responsibility for his negligent, careless or ignorant activities.

You might be interested in the legislation that has been proposed in some states concerning these herbicides. Perhaps the most strict regulations are

being proposed in Texas. They suggest that reports be made to the Experiment Station and should include location of sensitive plants, wind velocity and direction, as well as the pressure under which the chemical is applied. Additional proposals that are being presented may be of concern to most of you here today. Keep in mind the suggestions are coming from farmers themselves and represent so called "grass root" opinions. They propose to prohibit the application of 2,4-D in either the dust or ester form. They would have records kept of all sales of 2,4-D and would keep the records open for public inspection for a period of two years. They would refuse to allow any application of 2,4-D without a permit from the Experiment Stations and they are proposing that the State Aviation Board be empowered to regulate airplane spraying.

Most of you probably would consider many of those proposals far too drastic or as requiring too much red tape for efficient administration. It would seem that parts of the proposals would be difficult to administer and perhaps some of the suggestions are too strict. We must keep in mind, however, that these suggestions come largely from a group of cotton farmers. No other single group of agriculturalists have suffered from the drastic effects of herbicides to the extent of the cotton growers. As you know the cotton plant is extremely sensitive to 2,4-D whereas rice has proven an excellent crop for treatment. Thusly throughout the south in recent times there have been many claims brought before the public attention where 2,4-D, when applied to rice, has damaged neighboring cotton fields. What is just and fair in one state may prove to be either a hardship or worthless regulation in another.

One purely arbitrary part of the proposed bill is the amount of the suggested registration fees. In the model bill as presented by your committee there was a suggestion of charging a fee for each registration of an owner or operator and an additional fee of a lesser amount for each additional unit above the original registration. To illustrate that the amount of fees will probably differ in each state and that they are suggestions only, we might look again at the economic poison regulations. It is easy to see that each conference state has its own version of a fair and just amount to charge. For example one state law provides for a charge of $20.00 for each economic poison registered--this is not enforced. My own state of Kansas charges $15.00 for each of the first ten agricultural chemicals (economic poisons) registered and then $5.00 for each one over ten. This, we believe, is enforced. At the other extreme four states in the conference have no registration fee at all. The federal act does not require a registration fee.

There is an argument that the amount of the registration fee should be sufficient to cover administrative and regulatory costs and make the bill self-supporting; that it be not subsidized from public tax money.

In closing you might like to know just how much legislation has been enacted by conference states at the present time and some figures on states planning to submit bills in the immediate future.

There are nine states in this conference with an agricultural chemical or economic poisons law of some type. Five of these states, however, do not as yet include herbicides under such acts. There are seven of these states that have made known their plans for the introducing of an improved economic poisons

law during 1949.

The important thing in establishing a model herbicide law is that it may be easily enforced. Requirements to meet registration should be similar in all states so that once a product or a dispersing machine is registered in one state, permits to register in other states can be obtained without drastic changes or differences in specifications or procedure. The law must be such that it allows the consumer maximum usage of these important chemicals while minimizing the possible dangers.

It is hoped that the suggested bills may serve to prevent the enactment of ill-considered drastic legislation which would hamper and retard the beneficial use of herbicides in agriculture. If they do no more than that, they will have served one good purpose.

(The bill suggested by Mr. Noe is given in the report of Section III, Friday morning, Dec. 10, further on in these Proceedings).

MINNESOTA'S SHORT COURSE FOR TRAINING WEED WORKERS

Sig. Bjerken, Supervisor Weed Inspection

I have been asked to say something about the value of a Short Course for weed and seed inspectors. First, may I say that we feel that we have in Minnesota a well organized staff of weed and seed inspectors. We have some 1874 townships with the three town board members as weed inspectors, and 772 villages and cities with one inspector each, or a total of 6,394 inspectors by law, whose duties are to check every tract of land under their jurisdiction and cause to be destroyed or eradicated weeds existing on such areas. In addition to this, we have 84 out of 87 counties serviced by a county weed and seed inspector to assist and guide the local inspectors. The state is divided into nine districts with an inspector devoting his time to weed control, seed, feed and fertilizer inspection. One of their duties is to assist county inspectors with the organization of the program in the respective counties. Then we have the state office force, namely a supervisor of weed inspection, a supervisor of seed inspection, an agronomist, a state inspector and three girls in the office.

Surely a staff of inspectors such as this could not be expected to fulfill their important tasks without a training course, which led to the holding of a Short Course some four years ago, and we have had such a course yearly since that time with practically 100% attendance of the state, district and county inspectors, who in turn relay the information obtained to the local officials and the people in general.

The following is the type of a program which will be presented at the Course which is scheduled for January 24 - 29, 1949, inclusive:

PROGRAM

UNIVERSITY OF MINNESOTA
DEPARTMENT OF AGRICULTURE
AGRICULTURAL SHORT COURSES

University Farm, St. Paul 1

SHORT COURSE FOR WEED AND SEED INSPECTORS
January 24 - 29, 1949

MONDAY, January 24

Seminar Room, Fourth Floor, Agronomy Building

a.m.
8:15 Registration - Fee $6.00

H. K. Hayes, Presiding

10:15 Greetings . . . . . C. H. Bailey, R. A. Trovatten, P. E. Miller
10:45 Problems and Principles of Pest Control . . . . . T. L. Aamodt
11:30 Lunch

Bernhard Swenson, Presiding

p.m.
12:30 Weed Control in State Parks and Public Lands. D. W. Frear & E. V. Willard
1:30 County Weed & Seed Inspectors Association Meeting

TUESDAY, January 25

Seminar Room, Fourth Floor, Agronomy Building

T. L. Aamodt, Presiding

a.m.
8:15 Insect Surveys and Control Projects for Season 1949 . . . . A. W. Buzicky
9:15 Federal Seed Laws . . . . . E. R. Clark
10:15 State Seed Laws . . . . . O. A. Ulvin and V. J. Michaelson
11:30 Lunch

A. H. Larson, Presiding

p.m.
12:30 Seed Inspection Procedures by County Inspectors . . . . . O. A. Ulvin
1:30 Weed and Seed Identification . . . . . A. H. Larson and J. L. Larson
4:15 Seminar . . . . . Miner Helgeson, Leader

WEDNESDAY, January 26

Seminar Room, Fourth Floor, Agronomy Building

H. Macy, Presiding

a.m.
8:15 Chemical Weed Control Research . . . . . L. M. Stahler, R. S. Dunham, G. H. Heggeness
10:15 Chemical Control of Weeds in Vegetables . . . . . R. E. Nylund

10:35 Chemical Control of Woody Plants . . . . . L. W. Melander
11:30 Lunch

J. L. Larson, Presiding

12:30 Recommended Chemical Control Practices . . . . . R. S. Dunham, Ralph Crim
L. M. Stahler, John H. Miller
1:30 Weed and Seed Identification . . . . . A. H. Larson, J. L. Larson
3:30 Seminar . . . . . Wesley McKay, Leader

THURSDAY, January 27

Seminar Room, Fourth Floor, Agronomy Building

L. M. Stahler, Presiding

a.m.
8:15 Cultural Control of Weeds . . . M. L. Armour, R. F. Crim, R. S. Dunham,
Virgil Johnson, R. G. Robinson
10:15 Control of Weeds on Roads . . . . . C. L. Motl
10:35 Control of Weeds on Railroads . . . . . A. R. Miesen
11:30 Lunch

Sigvard Bjerken, Presiding

p.m.
12:30 County Commissioners and the Weed Control Problem . . . . . Wm. C. Minks
1:30 Township Supervisor Weed Control Problems . . . . . Milo Gilman,
Township Supervisor
2:30 Viewpoints and Problems of County Weed and Seed Inspectors . L. H. Smith
Cleo Goetzman
3:30 Seminar . . . . . O. A. Ulvin, leader

FRIDAY, January 28

Seminar Room, Fourth Floor, Agronomy Building

Ralph Crim, Presiding

a.m.
8:15 State Weed Laws . . . . . Sigvard Bjerken and V. J. Michaelson
10:15 Relation of Weeds to Insect and Disease Control . . . . . A. W. Buzicky
J. J. Christensen
11:30 Lunch

A. W. Buzicky, Presiding

p.m.
12:30 The Spray Machine Problem . . . . . L. M. Stahler, T. L. Aamodt,
Russell E. Larson
1:30 Use of Spray Materials and Labels . . . . . A. H. Larson, Arne Carlson,
T. L. Aamodt
2:30 Seed Laboratory Procedures . . . . . J. L. Larson
3:30 Seminar and Plans for 1950 Short Course . . . . . Sigvard Bjerken

SATURDAY, January 29

(Place to be announced)

A. J. Schwantes, Chairman

a.m.
8:15
to Commercial Spray Machine and Parts, Chemicals Demonstrations and Exhibits
12:00

We feel that a Short Course of this kind aids the inspectors in giving to the people of their county the latest information available as to weed, seed, and insect control and strengthens their position in carrying out their duties.

(Sig Bjerken report)

1948 Data as to Sprayers, Chemicals used and Weed Infestations reported by the County Weed and Seed Inspectors of the State of Minnesota, 87 Counties reporting.

1.	Number of Power Sprayers	10,353
2.	Number of acres of grain sprayed with 2,4-D	1,364,742
3.	Number of acres other than grain sprayed with 2,4-D	130,456
4.	Number of acres of corn sprayed with 2,4-D	54,611
5.	Number of acres sprayed with Sinox or Dow Selective	44,475
6.	Number of pounds of sodium chlorate used	1,522,671
7.	Number of pounds of borascu used	314,238
8.	Number of acres of field bindweed in State	35,950
9.	Number of acres of leafy spurge in State	18,053

EDUCATIONAL ACTIVITIES IN NEBRASKA
J. D. Furrer

One day this fall when I returned to Lincoln there was a note on my desk to call Operator 3 at Brookings, South Dakota. I complied. A very distinguished gentleman on the other end of the line informed me that the Program Committee of the North Central Weed Control Conference wanted a report from one of the states on their educational program in weed work. Mr. Klatt further informed me that Nebraska was selected at random to make this report. I might add that I am a little leary of the method Bill Klatt uses to randomize things.

I have decided to divide this report into two parts--"Some things we have done" and "Some things we ought to do".

In order that everyone has a fairly clear-cut picture of Nebraska weed control personnel and their jobs, I am going to sketch briefly our present set-up. We have three main divisions--research, regulatory, and extension. Our present research staff consists of Neal Shafer, agronomist with the Nebraska Experiment Station, who is ably filling the shoes of Noel Hanson but who refuses to wear his pants; Dayton Klingman, associate ecologist with the U. S. D. A.; Glenn Viehmeyer, horticulturist at the North Platte Substation; and from one to three graduate students.

The regulatory division consists of Loys Smith, State Weed Supervisor, and his assistants, Ed Aicher and Logan Heusel. Heusel is the newest member of the team and succeeds Clare Buskirk who recently accepted a commercial offer with the same organization with which Bill Klatt is affiliated. As many of you know, Mr. Klatt was Nebraska State Weed Supervisor not too many years ago.

So far I have listed the staffs of the research and regulatory divisions. The third and newest division is the extension division staffed by yours truly. The mission of the extension staff is twofold: (1) To make available for use by the people the information gained by research, and (2) public relations such as contact work with students, visits to and with commercial interests, and the building of closer relationships with other organizations. Because of the public's need for information on sprayers and 2,4-D during the past season, public relations were not given adequate attention.

Information on weed control is gotten to the people by publications of the research, regulatory and extension divisions, public meetings, news releases for press and radio, visual aids such as exhibits or material for exhibits at county and state fairs, and assistance to organized groups and clubs.

Much credit for the success of Nebraska Extension work in weeds must be given to the Division of Noxious Weeds and their 86 organized weed districts. Many of these organized districts have hired managers who operate the district's equipment, keep books, help farmers with their weed problems, and carry on a general educational program in the county. During the past year the members of the Division of Noxious Weeds and the Extension Service attended 203 meetings at which recommendations for the use of 2,4-D, equipment, and other timely weed topics were discussed. Of these meetings, 85 were the annual meetings of the organized noxious weed districts held during the first three months of the year.

Many of you are familiar with the Nebraska Weed Conference and Chemical and Equipment show held each year during the forepart of January. Last year exhibits of 48 commercial organizations were viewed by several hundred people. On January 12 and 13, 1949, we are anticipating an even larger show.

Besides the State Weed Conference, 14 district chemical and equipment shows are held annually. At these district shows the chemical and equipment dealers from six or eight nearby counties are given an opportunity to display and demonstrate their sprayers and herbicides. A speaking program also constitutes part of each day's activities.

As weeds began to show up this past spring and people began to realize how little they actually knew about the sprayers they had purchased, there developed an intense interest in the calibration of equipment. I think an outstanding

example of what can be done on calibration was demonstrated in Richardson County, Nebraska.

The county agent, Tom Aitken, arranged eight meeting places during two days throughout the county, designating the hour we would be at each place and the purpose of the meeting. Most of the meeting places were simply shade trees along a country road or rural school yards; but nevertheless there was an average attendance of 35, and at each stop there were a couple of sprayers calibrated by simple methods. By simple methods, I mean without complicated formulas and charts. Questions were answered on sprayers and chemicals. I am sure a large portion of the farmers went away from these meetings with a feeling of confidence that the machines they had purchased could do a decent job of spraying.

During the past year, 73 news items on weeds, herbicides, and sprayers were released. Over 42 thousand bulletins were distributed, and several radio broadcasts were made. Exhibit material was furnished for many local and county fairs as well as for state fairs. Nine pre-emergence plots using 2,4-D were established over the state. Twelve demonstrational plots using other herbicides were also established.

This year at the Nebraska State Fair two Johnson brothers from Fremont put on a demonstration with spray equipment which some of the State 4-H club leaders referred to as another milestone in 4-H demonstrational work. Because of the nature of the demonstration, it was impossible to conduct it in the usual space. It was necessary to hold it out-of-doors. The judges had to go to the demonstration instead of the boys going to the judges. Their blue ribbon demonstration was on the losses due to weeds, the effects of 2,4-D on weeds, and desirable features in a sprayer. The effects of 2,4-D were demonstrated by displaying potted sunflowers which were sprayed 10, 5, and 1 days before the demonstration.

We could go on and relate other work, and so could all the other states represented here, but time is too short.

During the time we were doing the educational work just reviewed, the task seemed pretty big. But now as one looks into the future and views what is left to be done and then glances back, we have come only a short way. Let us just take a glance at a few of the problems facing us in the future.

How are we going to stimulate urban interest in weed control? Some of you may think we don't need it. I am not one of you. The unsightly growth of weeds that so often faces us as we approach a city is appalling. Many of these areas could be made into parks or playgrounds by simply planting adapted grass, trees, and shrubbery. In many cases vacant lots, right-of-way, and other similar areas are nothing but weed patches. It is going to be a difficult task to get these areas cleaned up. One approach we are going to try in Nebraska is from the health angle. We have a publication called "Nebraska's Hay Fever Weeds". It lists the twelve most bothersome weeds, such as ragweed, pigweed, cocklebur, fireweed, and others. There will be available for meetings colored slides of the hay fever weeds. The Home Economics Department is helping with the program by developing a project lesson on hay fever. By this means we are hoping some of the women will take up the battle. We all know that men hate to have women agitating them to get something done.

Education of our young folks--4-H'ers, Future Farmers of America, Boy Scouts, Camp Fire Girls, and others--needs a shot in the arm. Incentives would go a long way in the promotion of this very vital educational work. Trips to the National Club Congress in Chicago are looked forward to by every 4-H club member. Herbicides furnished to Boy Scout troups or FFA members at a small cost would encourage weed clean-up programs in many localities. Posters on losses due to weeds and how weeds affect health would undoubtedly open the eyes of many.

Educational work among people of all ages could be stepped up by sponsoring more tours and weed identification contests. Speaking of identification reminds me of one particular meeting held last spring. Samples of various weeds had been collected. Among them was Russian knapweed. It was pointed out that Russian knapweed could quite readily be identified by its bitter quinine taste. One old whiskered gent stripped off a handful of leaves from the specimen, tossed them into his mouth, and commenced to munch them. It wasn't too long before he began to spit and sputter. He had learned to identify Russian knapweed even though he was 73 years old.

Much of the current literature we now have is not written so it is readily understood by the layman. Time and time again, I have been asked, "What do you mean by a third of a pound or two-thirds of a pound of 2,4-D acid? The stuff I bought came in a gallon can." When we started talking in terms of pints of the various liquid products, it was much less confusing to many.

Manufacturers of chemicals could make the extension job much easier. The printing of simpler instructions on containers, the addition of the pounds of acid contained in each pint, and the inclusion of all pertinent data would meet with wide approval among farmers. The only way to tell whether some of the products sold in Nebraska last year were esters or amine salts was to taste them or mix them. We have been discouraging the use of such material. For field use we also discouraged the use of low concentrate materials. There should be some standardization of the 2,4-D acid content in those products manufactured for consumer consumption. Such a standardization would prevent some of the over dosage and some of the under dosage which now occurs.

Chemical and equipment manufacturers owe it to the good of their organizations to do something about educating their dealers and other representatives in the field of weed control. Time and time again we encountered dealers who knew nothing about the products they were selling. It wasn't uncommon to hear remarks like, "This material is better than 2,4-D because it won't make your cattle sick if they drink it." The miracle material in question usually contained a reasonable amount of 2,4-D. One day at a meeting I heard a dealer remark, "A gear-type pump won't do the job." After the meeting, it was necessary to disassemble the pump on his sprayer and show him a gear-type pump.

We in extension are probably at fault for not giving more attention to the commercial phase of educational work. This coming January 14 and 15 we are planning a short school period at the College of Agriculture for any one within the state who desires to learn more about weed control work. On January 21 and 22 we will be cooperating with a chemical company in Omaha on a school for those who do aerial applications of insecticides and herbicides.

We have a tremendous educational job ahead of us. We have the new chemicals 2,4,5-T, IPC, TCA, and others, some of which are already available to the public and which will require the efforts of all of us if they are to be used in the right manner. While the boom period of herbicides is on, let us do something to keep it at a high level. We must be cautious and we must build a solid program that has appeal to the people. Through the coordinated efforts of research, regulatory, extension, and commercial interests, it can be done.

SAFETY ZONES IN A WEED CONTROL PROGRAM

Charles J. Gilbert

When this title was first mentioned as a discussion topic for this conference, it seemed like a good one to me,--that is, a good one for someone else to speak on. When I was asked to speak on it, it certainly lost some of its attractiveness and that trend has increased as the days went by. However, this title does bring up some thoughts that offer challenges to our planning ability and program building.

Several dictionaries which were consulted offered numerous definitions on everything from safety pins to safety valves but not one of them defined a safety zone. Without any help from them, therefore, I shall give my definition of a safety zone: A place where you may go, without danger, (theoretically) while you make plans for your next necessary move. Applied to a weed program it might mean, a place or a person who will take good care of the program while you are busy with some other phase of your job.

If there are safety zones where other people will protect your program, encourage your program, support your program, defend your program and promote your program of weed control, you and your associates can move along, to develop new fields of effective effort.

Not long ago a weed supervisor was in conference with the attorney general's office in his state and one of the assistant attorney generals exposed his lack of understanding of weed control by saying that when he was on the farm he pulled his cockle burrs, and why couldn't farmers do the same now. This intimated that in his opinion the weed program and the weed law was an unnecessary appendage on the body politic. Of course, he admitted, that the time when he pulled his cockle burrs was 24 years ago. He obviously had not seen the 100 acre, 200 acre, or even 400 acre fields of densely growing cockle burrs which have appeared in certain areas during the last 4 to 6 years. He further stated that August fallow would control any weed that grows. He insisted that there was no difference in control between annuals or perennials and I am sure he did not know the difference. There may be few favorable rulings or opinions of law from him until he sees noxious weeds still growing after months or even years of continuous fallow; or until he sees some field of otherwise good grain not worth harvesting or unharvestable because of weed growth. There will not be a safety zone for weed control with him until he has become familiar with the problem. He does not know weeds, but that situation will be remedied in time. The people must know the damage, danger and difficulties of weeds. The makers, interpreters, and administrators of our laws must be safety zones for our weed programs.

A township in Moody county, South Dakota, in the winter of 1948 organized as a neighborhood to fight weeds. Two neighborhood 'weed fighters' had been selected as neighborhood leaders. They helped, encouraged, organized and promoted weed control, weed eradication and weed prevention. Then came the pay off. When summer came, two farmers, just two, in the neighborhood failed to destroy their weeds, and perennial sow thistle and Canada thistle seeds would soon be flying to infest and spoil new fields. Was the effort of an entire community to stop the spread of weeds, to be laughed at, go for naught, or die because two people would not cooperate? Not in that community. Twenty three of those neighbors signed a petition for enforcement; the county weed board chairman was seen; they consulted their county agent and he put in a call for the state weed supervisor. The supervisor made the appointment and with the two neighborhood leaders, the county chairman and the county agent, checked the neighborhood and found only the two fields of noxious weeds. One operator was found and he became quite arrogant. He soon learned, however, that he was alone. He admitted the neighborhood had done an excellent job, and that he was the one that was out of step. Every excuse in the book was offered as to why he could not get the job done but the persistence of his neighbors won. They told him they did not want to have the law enforced on him. They had no desire to quarantine his land, damage his crop, cause him unnecessary expense or get him in trouble with his landlord. But by all the stars of the big dipper they wanted those weeds taken care of and proposed to see that it was done. He promised. He did what he said could not be done, went out in the drizzling rain to cut them down. He did what he did not want to do, destroyed part of his flax crop to destroy the weeds. When part of the job was not satisfactory to the neighbors, they called his landlord 150 miles away and told him the the story. When the landlord called his tenant out of bed that night the job was completed, satisfactorily, on Sunday, which was the next day.

I call your attention to several safety zones in this instance. An organized neighborhood, organized to save land from infestation; to save dollars in crops; to save needless labor and useless expense; to save the good name of the neighborhood in that county and to conserve the investment of the people.

A weed program that does not have organization as its base is short of vision. An organized community is a valuable safety zone.

Another safety zone for weed control in this neighborhood was local public opinion. Without public opinion developed through organization there would no doubt have been many more fields with noxious weeds; without public opinion there would have been no petition; without public opinion the good farmers who were fighting their own weeds would never have had the courage to lead out; without public opinion the operator would have dared the law to take its course and all the involved procedure of legal enforcement would have had to be used. A weed program that does not include recognition of the value of public opinion has the brakes set on an uphill pull.

There is another safety zone that this incident brings to attention and that one is to have interested, informed and intelligent landlords. The kind that will cooperate with a good tenant, instruct a willing one and 'lose' a poor one. A county weed program that neglects the opportunity of having the landlords, local or non-resident, on the side of weed control has not tapped one of the best means of building a safety zone.

The support of agricultural extension forces has sometimes been taken for granted and sometimes been ignored. In our state the weed law provides that the educational phases of the weed program rest in the extension service. A weed program in any state that does not have close and friendly relationships with the extension service is failing to use all of its ammunition and will find effectiveness difficult to attain. A friendly agressive county agent is a desirable safety zone. He, like the other safety zones, sells your program while you are away and while you sleep.

The case just mentioned had all these safety zones established and others. A cooperative and well informed county board of commissioners that took care of its roads, has now appropriated $8000.00 for a county weed supervisor and his work has shown interest and aggressiveness in demonstrations and education, and has expressed confidence in the program.

Many people feel, (and some commissioners feel the same way) that members of a board of county commissioners are elected to spend as little of the people's money as possible. Rarely does one find the attitude that their job is to invest the tax money of the people in such a way that the greatest returns in savings, services and satisfactions are accomplished. Many of our counties produced from the land crops worth in the neighborhood of ten million dollars in 1947. I suppose to many of you that sounds like chicken feed but with us it is still big money. No one yet has quibbled to me about the figure of 10% of the crop value as a minimum figure in computing weed loss, not even a county commissioner. 10% of ten million dollars is $1,000,000 as the loss from weeds from such a county, which does not take into account all the costs of weeds. Many counties do not have 1/10 of that much as their annual budget. Is it or is it not a good investment to spend $10,000.00 to attempt to get a 1000% return or more on the investment and to save that amount several times over in the coming years? Is it a good investment to spend some money that can make a return of almost any county's tax budget? An educated, well informed group of county commissioner boards is a marvelous safety zone.

Not long ago one of us chatted a bit with a newspaper man. He was a small town editor and liked it. He felt that at long last he was not going to be a prophet crying alone in the wilderness against the spread of noxious weeds which were taking over good land and stifling its production. Have we neglected the safety zone of editorial comment and real fundamental news stories of who, what, where, when, why and how?

From the number of out of state cars which we see each year during hunting season it appears that people of other states must recognize the superior game bird advantage of South Dakota. To make that possible there has been established by state and federal governments large game refuges and nesting grounds for these birds. On one of these large areas, where few people ever go except the caretakers and occasional visitors there was located this past spring a considerable area of thickly growing perennial peppergrass, otherwise known as hoary cress or whitetop. At that time it was the largest known area of that weed in the state. Further survey work on this preserve found heavily infested Canada thistle, perennial sow thistle and leafy spurge areas. Governmental agencies have sometimes been criticised for their slowness in action. Lack of personnel, lack of funds, lack of authorization, lack of this and lack of that are given as reasons for not being able "to take care of it this year". We have heretofore

and wish to again compliment Homer Bradley, superintendent of the preserve, and the Wildlife Service, for their excellent and effective cooperation. They could not buy a spraying machine so they borrowed one from a neighboring farmer. They could not buy 2,4-D, so they made a loan from the Soil Conservation district nearby. The entire area of perennial peppergrass was sprayed at once before the seed could form. One day as we stopped by to see the refuge and its weeds we found a man operating a broom type boom down along the shores of the lake spraying large areas of sow thistle. A big job, yes, but being tackled with the best they could get in equipment and with a lot of push and cooperation. This area had been a stumbling block to weed control in that county and in that neighborhood. The adjoining farmers would usually say "why should we kill weeds when the whole area will be seeded down again, from the game land?" It is not a stumbling block any more. The farmers are now the ones with the low score and must come from behind to match the effort of Homer Bradley and the Wildlife Service. They are making plans to do that very thing this year. Homer and his crew have made us a very fine safety zone for our weed program, for thousands of acres of land, and we hope, for two states.

The Fish, Game and Parks Commission has already cooperated in a number of outstanding instances in controlling noxious weeds. Time does not permit telling the details of the difficulties, procedures and results of their cooperation.

The School and Public Lands Dept. have gone to the limit of their present legal powers to become safety zones for weed control.

Every mile of railroad in one county was surveyed and all noxious weeds treated. Our state highway department has given splendid evidences of cooperation in many instances.

This discussion would be very incomplete if one of the largest and most important of our safety zones were to pass unmentioned. The South Dakota Crop Improvement Association was probably the most active sponsor of our weed program and law, and still is one of its most active supporters. Twenty five hundred growers of certified, registered and pure seed, in some fifty counties are active cooperators and defenders of the weed control program. Wherever they are the program is encouraged, protected, defended and supported.

The State Horticultural Society is very active in their support of the program. Soil Conservation supervisors, leaders, and conservationists assist local people in their programs. They loan equipment and give service to their cooperators. The County Commissioners Association of the state has its president as a member of the State Weed Board.

Do not think from the above that the weeds are all dead or dying in South Dakota. There are many more, distressingly many more, but we believe that the program which has been started, and for which we have been trying to build safety zones, if you please, is on its way to serve our people.

In closing, with your permission, I will read something that one of our supervisors wrote and which was carried in the Dakota Farmer as a special editorial feature:

"BY THE PEOPLE"

The weather outside was definitely cold--24 below zero. Some of the men present had come by horseback; some had walked to the main highway to be picked up by a neighbor; a few could drive all the way if the car started. The more than 20 men were making their plans to kill the weeds in their community and in their neighborhoods on their farms--conservative, serious, economy minded, but deadly in earnest. They do not propose that weeds shall further take over their land or their cash.

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Eleven men of various ages, apparently 16 to 60, sat not too comfortably in seats made for much younger folks, in a country schoolhouse. The uncertain light of a lantern made bright some of their faces and left others in shadow. They were listening intently while their county agent explained some of the things they could expect from the new weed killing agent, 2,4-D. They told of their problems; the size of their creeping jenny patches; to what crops the fields were to be planted this year, and their plans for control this year. How about the neighbors? They have weeds too. They should be in the program, also. How? Neighborhood organization is the answer. "O.K.," they said, "let's do it."

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A large building filled with exhibits of sprayers, pumps, chemicals, trailers, and tractors. A crowd of possibly 1,000 people was expected for the two-day conference. The first day over 2,000 people attended the meetings and studied exhibits. The next day a lot of new faces were present. Farmers, county commissioners, county weed boards, commercial spray operators, township officers, dealers, bankers, merchants, and other owners of real estate filled the exhibit building and meeting auditorium for two days, securing weed-killing information. A weed control program by the people was under way.

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This setting is about 12 miles from town, near a country store. A pasture containing a baseball diamond was the testing ground. They said 750 people were present. Spraying equipment was being given an actual field demonstration. A loud-speaker was in use and from it was coming the story of sprayer calibration. The machines went over the measured course determing their speed; the nozzles were being checked for volume of delivery per acre; the tanks were checked for capacity, and the amount of 2,4-D figured for mixing. People were learning the proper methods of using new things in a weed control program which will succeed because it is a program by the people.

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The table had many papers on it. There were some survey maps, a county weed record book, some sheets with notes on them. The notes were about things to be done. A small group, only seven, sat around the table. But these seven men had been elected by the folks out home to develop, formulate, and carry out a county weed program for them. Of their number, three had been elected as a county weed board. These seven men, with their weed board, were to work with

their county commissioners, their county agent, the highway superintendent, the township boards, the state highway commission, the railroads, perhaps the fish and game commission, and the commissioner of public lands, to stop the spread of, and the terrific loss from, weeds. They were given their task by the people.

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The best safety zone of a weed program is the people, all of the people.

Thursday Afternoon, December 9

Centennial Auditorium

GENERAL SESSION
W. W. Worzella, Chairman

MACHINERY AND METHODS OF APPLICATION
W. P. MacDonald in charge

SPRAYING EQUIPMENT FOR HERBICIDES AND OTHER METHODS OF APPLICATION

W. P. MacDonald, Minnesota

I am going to open these remarks by saying that the perfect sprayer for the application of weed control chemicals will never be built. That statement probably can not successfully be challanged as the difficulties involved in the construction of the perfect sprayer are economic rather than mechanical. If it so happens that you have some pretty firm convictions as to what a weed sprayer should consist of, you will not have to do more than ask the gentleman sitting beside you what his opinion is to get into an argument.

The kind of machine that will be ideal for one farmer lacks several features which are of utmost importance to his neighbor. For instance, one prospective buyer needs a machine principally for use on row crops. The next individual will spray only small grain. Another farmer will use his sprayer only for field work, while his friend also wishes to control livestock parasites and it has been recommended to him that he should buy a sprayer capable of developing pressures up to 400 pounds.

For very good economic reasons farmers decided long ago that one piece of traction equipment will not do all the jobs on the farm. When a man sets out to buy a gasoline-powered vehicle he must decide whether it is to be used primarily for a vacation trip to California, in which event he would presumably buy an automobile, or is he principally interested in using this machine for pulling a plow and filling a silo - if so, it would seem quite logical for him to purchase a tractor. To my knowledge, no one has as yet seen fit to combine all of the features of a Chevrolet passenger car, a Ford pick-up, a Dodge truck and a John Deere tractor in one package.

It is scarcely more logical to expect a manufacturer to put out a sprayer that will fit the needs of 40-acre as well as 400-acre farmers; spray row crops

as well as close drilled crops; develop pressures from 40 to 400 pounds; deliver volumes of from 5 to 50 gallons per acre, and at the same time fit everybody's pocketbook. If a manufacturer should decide to offer a machine embodying these and a great many other features it is quite unlikely that he would make many sales as the cost of the unit would be prohibitive. It then becomes the problem of the sprayer manufacturer to decide what features he must provide in his equipment in order that he may aim at the broadest possible market, with no thought to offering a sprayer that will meet all of the requirements of all of the buyers.

During the past ten years in the hard spring wheat area we have had a great deal of experience with weed control sprayers of various kinds. I believe it is quite apparent, however, that the conditions which must be met in the area mentioned are not necessarily typical of those encountered in other states and provinces represented by the North Central Weed Control Conference. Therefore, when it was delegated to me to make this presentation today, I thought it would be well to obtain a survey of opinion from the entire group. Accordingly, questionnaires designed to obtain information on spraying equipment were sent to Conference members in all of the states and provinces represented. I think you will be interested in a summary of the replies. I might say here that information was obtained from a total of 14 states and provinces, more than one reply being received from some states.

The first question asked had to do with the popularity of several types of applications. A tabulation of the results shows that during the past season approximately 90% of the acreage treated with weed control chemicals was covered by ground sprayers. Approximately 9% of the acreage was treated by aircraft, 1% with dusters and a trace with blower or turbine type equipment. In general, it seems that during the past season a big majority of the users preferred ground operated sprayers. There was one noticeable exception in the winter wheat area where it was indicated that the division between ground sprayers and aircraft was 35% to 65% with the latter percentage being made by planes.

Another question asked was if there was a trend to any particular type of application. Thirteen replies showed the trend to be to ground sprayers, 2 replies showed a trend to aircraft and one suggested an increasing interest in dusters. In general, the reasons given for the trend favoring ground sprayers was that this method was handy for the average farmer and possibilities of drift injury were minimized. The one individual who suggested greater interest in dusters said it was due to the inability of farmers to obtain water. In the two cases where aircraft application was coming to the front, the reasons were that this method was very fast and relatively safe where large acreages were involved and there are few susceptible crops. It was also mentioned that where treatment was late in the season, aircraft caused no mechanical injury associated with ground rigs.

On the question of the proper volume of solution with ground sprayers, most replies indicated that the range was from 5 to 10 gallons. The maximum volume suggested was 20 gallons per acre. Several who suggested 10 gallons rather than 5, gave as their reason that the precipitate difficulties encountered last year were reduced by the greater per acre delivery. A few suggested that they felt 10 gallons gave better coverage than 5 where heavy foliage was involved.

I must confess that as a representative of a firm particularly interested in trailer type sprayers, the answer to the next question was somewhat disconcerting. In this question we asked if the general preference was for tractor mounted or trailer type sprayers. Of those answering this question, 15 said that the preference was for tractor attachments and only 2 said that farmers preferred trailer sprayers. In all probability the greater interest in tractor mounts is due to the fact that this type equipment can be sold for 50% or less of the price of good trailer sprayers. We do have every reason to believe that trailer types will continue to be popular in the small grain states.

A question was asked as to the principal difficulties encountered with sprayers, dusters and planes. Nozzle clogging was far the most popular cause for complaint with sprayers. In all fairness, I believe we should state here that this inconvenience was not necessarily due to faulty construction of equipment. It is certainly well known that several 2,4-D preparations gave difficulty last year when used in high concentrations with hard water. Undoubtedly the precipitate which resulted from this combination had as much to do with clogged nozzles as the improper screening in the line or nozzles themselves. Other criticisms of sprayers included weak boom construction, unsatisfactory pumps, inadequate clearance for row crops, and lack of a marker for the area sprayed. Dusters were criticized principally because of the drift hazard involved. Aircraft applications were criticized for the same reason and for lack of uniformity in coverage by some operators. We asked how methods could be improved upon for the future. Several suggested that chemicals should be improved to make them more compatible with hard water. This, as has been pointed out, should not be a criticism aimed at the equipment itself. Among other suggestions for improvement were better and more accurate methods of calibration, changes in design of sprayers for adaptation to row crops, improvement of nozzles, faster pumps for refilling tanks, more rugged construction and better control of drift.

Additional comments received brought out one important point which equipment manufacturers should heed for the future. That is that all equipment be thoroughly tested for performance in the field before it is placed on the market.

The foregoing sums up the information obtained from our survey and I believe it covers points which should serve as guide posts for manufacturers of equipment. As stated previously, it is not at all likely that any one sprayer will combine all of the factors required by all of the potential buyers. At the same time, it is true that there are certain minimum and essential features which must be embodied in all sprayers.

The tractor-mounted sprayer has an advantage in that it is strictly a one unit, one-operator machine. When mounted on a row-crop tractor, it has high clearance which adapts it to a wider range of crops. As it is driven from the tractor engine, there is an ample and dependable source of power. The single unit makes only one set of tracks in closely drilled crops. For the most part tractor-mounted sprayers represent a smaller initial investment for the farmer than do other types. It is also true that most tractor-mounted sprayers provide for the boom mount ahead of the tractor which is a convenience for the operator.

The principal disadvantage of the tractor-mounted sprayer is the inconvenience involved in putting it on and taking it off the tractor. Quite frequently the farmer has a small patch of weeds which need attention. Perhaps at that particular time he has his row-crop cultivator mounted on the tractor. To spray, it is necessary for him to remove his cultivator, mount his sprayer, and after spraying he must remove the sprayer and remount the cultivator in order to get back to his corn. All too frequently under these circumstances, the weeds do not get sprayed. The matter of carrying water on a tractor-mounted sprayer has also been quite a problem.

It is true that no one make and model of tractor presents much of a problem, but when the manufacturer tries to design brackets suitable for use with his sprayer on all makes and models of tractors, he meets with some difficulty. While having the boom ahead of the tractor may be considered an advantage for post-emergence spraying, it would seem to be a disadvantage if pre-emergence spraying comes into favor. Disturbing the soil surface after pre-emergence spraying appears to defeat the purpose of the operation.

Skid-mounted sprayers, while usually higher in price than tractor mounts, are generally priced lower than those provided with a running gear. Many farmers are now equipped with rubber-tired trailers of various types suitable for use with skid-mounted sprayers. These machines may also be used with most types of farm trucks and pickups where a tractor is not available. It is generally not very satisfactory, however, to use equipment built for road use at low speeds on soft ground - at least not on extensive acreages. It is also true that the rate of speed of such equipment is difficult to control properly. With skid-type sprayers the booms are generally mounted behind the unit which has the advantages or disadvantages previously mentioned. If this type of sprayer is mounted back of a truck cab, the driver has little opportunity to observe operation of the boom when traveling.

Trailer-type machines are provided with their own running gear and have an advantage in that they may be pulled by any type of traction equipment. There is a big convenience in being able to simply drop in a coupling pin to attach the sprayer. Having the tank mounted so that it is mobile does away with lifting and moving awkward assemblies. Booms may be mounted either ahead or behind the sprayer proper but must be mounted behind the tractor, or other power. One disadvantage of the trailer machine is that the initial cost is higher. Having extra wheels on the ground may also result in greater crop injury, particularly if the crop is in an advanced stage of growth. In general, however, we have not felt that wheel track damage is significant where the soil is fairly firm and the crop is sprayed at the proper time .

A sprayer must of necessity be made up of four component parts. These are: A tank for carrying the solution, a boom for uniform distribution, a pump to move the solution and a source of power.

The tank may or may not be an integral part of the unit. Many sprayers, tractor-mounts in particular, are furnished without tanks. The tank must provide sufficient capacity to permit covering a considerable acreage without refilling, yet not be so heavy when filled as to be cumbersome or difficult to move on ordinary fields. If 5 gallons per acre is considered a standard for 2,4-D, then the tank should probably have a minimum of 50 gallons and a

maximum of 150 gallons capacity. If dinitro chemicals are used, more water capacity is required as these chemicals generally require that the solution be applied at upwards of 40 gallons per acre. A 100-gallon tank at the 5 gallon rate will permit spraying 20 acres without refilling. At 40 gallons per acre, with a 400-gallon tank, only 10 acres can be covered.

Prior to 1948, most all tanks were made of steel with a few of wood construction. This year a majority of the sprayers have aluminum tanks. So far aluminum seems to be a good material in that it is not subject to corrosion. Of course, aluminum is a difficult metal for the average farmer or small machine shop to work on if repairs are needed.

The shape of a tank is not particularly important, but there should be a minimum of sharp angles and corners which may collect foreign material. Consideration must be given to distributing the weight when the unit is assembled on trailer-mounts. The center of gravity should be kept as low as possible. It is important that tanks be built of materials that do not easily corrode. That problem may be rather difficult to overcome as there is such a variety of new agricultural chemicals being offered. Their action on metals has not been fully determined when used alone or in combination. An agitation system effective throughout the entire tank is certainly desirable and for the use of wettable DDT an adequate agitation system is an absolute essential. Provided the pump has sufficient volume, it is a relatively simple matter to provide a bypass whereby the excess flow from the pump can be returned to the tank for agitation. The tank should have a large fill opening to permit cleaning, and the outlet from the tank should be so located that it can be completely emptied either by the pumping system or gravity flow. Some provision should be made in the fill opening to screen the liquids as they are put into the tank.

We need spend little time in discussing the source of power. Power is normally obtained either from an air-cooled gasoline engine, or a tractor takeoff. Both have proven quite acceptable.

This then leaves us the matter of pumps and booms. Undoubtedly, major improvements need to be made on these two items. Of course, when we mention booms we must also think of nozzles which are a part of the boom assembly. While some may think that this is an unjustified criticism, it seems to me that manufacturers of both pumps and nozzles have been reluctant to face the facts in developing items for weed sprayers. Certainly the old attitude has changed in recent months. Not too long ago when we asked for a special pump or nozzle, we were told that this or that company had been in the business of manufacturing these units for a great many years and had exhausted the possibility for design, therefore, something in their present line must be exactly what was needed for weed control work. Of course, it has developed later that such was not the case and both pumps and nozzles designed particularly for low volume spraying are now starting to appear. Certainly no one is willing to admit yet that the ultimate in pumps or nozzles has been achieved. It is true we will have to decide just what we want for a particular sprayer and be satisfied with certain limitations.

Pumps which provide pressures of from 30 to 50 pounds per square inch appear to be entirely adequate for use with herbicides. Most farmers, however,

want a machine that can be used for other purposes. For general farm use of DDT, a pump that will develop up to 100 to 125 pounds per square inch is preferred. Pressures in this range have given good fly control on both livestock and buildings. Some adjustment must be provided so that the pressure will remain constant at the desired point. An accurate pressure gage is essential. This gage should be located between the boom and any strainers that are in the line.

All types of pumps are being used. Probably the majority of the sprayers are equipped with brass-gear pumps, but good success has been obtained with several types of rotary, centrifugal and rubber-paddle pumps. With brass-gear pumps, or others, where the tolerances are close, abrasive foreign material in the water cuts the pumps out quickly. Otherwise gear pumps are very nearly foolproof. Centrifugal pumps give good spraying pressure, but do not prime readily. Rubber-paddle pumps are not particularly affected by abrasives in the water, but may be quickly damaged if they are run dry. Generally speaking, the rubber pumps develop only a minimum of pressure. Pumps which can be coupled directly to the source of power have an advantage in that there are fewer moving parts and the safety factor is increased.

The perfect pump should be completely resistant to abrasive materials, it should have a pressure range from 40 to 300 or 400 pounds per square inch, it should have high volume capacity for tank filling against no pressure and either an internal or external pressure relief valve to bypass a large percentage of its output when actually spraying. Of course, it must be made of non-corrosive materials and if non-metallic, must also be resistant to oily chemicals or diluents. It must be quick priming which ordinarily means it will be of a positive displacement type. Either the pump itself or its attendant valve arrangement must provide for immediate pressure relief on the boom to prevent nozzle drip. It goes without saying that it should be simple and understandable and long lived under ordinary conditions and usage. Some really new ideas are being incorporated into pump designs at this time and I am sure we can be confident that all, or nearly all of the requirements mentioned will be found in popular priced pumps in the near future.

It is very gratifying to note that the 1949 model sprayers appear to have overcome most of the boom and nozzle shortcomings found in previous machines. Another speaker will discuss nozzles in some detail. Past experience has indicated that nozzle failure was due largely to improper screening. All too often we saw nozzles that became stopped when the screen was completely free of foreign material. If properly constructed, a nozzle, in theory at least, should never clog. If it were adequately screened this would be true, but under certain conditions we would have clogged screens but not clogged nozzles. Nozzles, of course, should be flexible enough so that a change of tips would change delivery rates. They should be easy to clean and non-corrosive. They should throw the widest angle possible and the most uniform pattern consistant with simplicity of design. Most individuals familiar with the operation of nozzles under field conditions will agree that real progress has been made in the last year.

Some mechanical device or chemical needs to be developed to mark the area sprayed satisfactorily. When an almost colorless solution is applied at low volume, the sprayed area is not discolored and, as a matter of fact, is scarcely wetted. Any lapping that occurs results in double application which may be

harmful to the economic crop and in any event is wasteful. If someone will develop a good system for marking, he will be doing a real service to sprayer operators.

Proper calibration of sprayers is very important. From the practical standpoint, it doesn't do the farmer much good to know that the sprayer he purchased will apply 5 gallons of solution per acre at 30 pounds per square inch and 4 miles per hour, if he doesn't know how fast his tractor moves with the kind of load he will be pulling. We believe that every sprayer should be calibrated in the field under conditions similar to those that will prevail when actually spraying. Sprayer calibrating devices have been offered which will do a good job if properly used, but generally depend on the results obtained with one nozzle, which may not truly reflect the performance of the entire boom.

The sprayer manufacturer will have to make his own decision as to whether or not he wants to offer a machine with such refinements as double action swing joints on the boom, buffer or caster wheels to protect or support the boom, clearance and width of treads suitable for use with row crops, built-in calibration devices and many other features of importance to individual prospective buyers.

Because of the greater preference shown by our customers for spraying equipment, my firm's experiences with dusters has been very limited. I was fortunate in being able to obtain some suggestions from Mr. L. A. Wollam, representing the International Elevator Company at Great Falls, Montana. Mr. Wollam is a recognized authority on dusting equipment in his state and doubtless his suggestions on dusters will be of interest.

Satisfactory dusters must have a set mechanizm which is positive and accurate throughout the entire application range. The mixing chamber must be efficient to insure uniform air-dust mixture. The total air volume must be engineered to balance total discharge outlet area. Too great an air volume results in back pressure and turbulence within the boom. Too little volume prevents dust distribution at boom ends. The dust must be discharged through booms tapered to overcome friction and normal loss of air velocity at boom ends. Air volume also enters in here. Too much air means heavier distribution at boom ends, too little causes heavier distribution in the center of the booms. Discharge openings should be calibrated at about 3-inch intervals for uniform coverage. Some boom designs require that these be graduated in size. A boom hood, either ahead of or behind the boom, is necessary to break up air currents caused by the duster's forward motion. Wheels should be provided at the boom ends to maintain uniform height above the weeds. The hopper must have a properly designed agitator to prevent packing and providing uniformity of application whether the hopper is full or nearly empty. Proper designing for the fan and fan housing are essential. Improper design may result in the dust and air separating as the tendency is for the dust to be forced out to the edges of the fan housing which will cause heavier feeding at the first boom openings reached. Failure to meet this requirement resulted in faulty operation of some of the earlier dusters but has been largely overcome at this time. The boom itself must be free of all obstructions which may result in turbulence and a building up of dust particles. In this connection booms that are drawn or rolled to taper are much superior to those which are reduced by using successfully smaller sizes of pipe.

The improvement of ground equipment for the application of weed control chemicals should by no means be considered the sole responsibility of the machinery manufacturer. Commercial and governmental research chemists have an important part to play in improving the physical properties of the chemical in either dry or wet form. The engineer and chemist to produce a satisfactory sprayer, duster, or chemical, must be continually in touch with the man who is actually using their product under field conditions. They have got to get out where the weeds are and visit with the farmer who is making the ultimate test. The engineer who availed himself of the opportunity to discuss his sprayer with a customer in the field during the past season was probably surprised to learn that there may have been some faults in design or weakness in construction that never showed up on the drawing board.

A SIMPLE TECHNIQUE FOR SPRAY NOZZLE TESTING AND SOME RESULTS BY

G. L. Shanks

The use of 2,4-D as a herbicide on cereal crops has resulted in a number of developments in spraying technique. The relatively low value of the crop coupled with the tremendous acreages necessitated changes in spray equipment. In orchard spraying the relative volume of liquid required is small when compared with that required for cereal acreage. In insect control only the cost of wasted spray is a factor but in the spraying of grain crops we must consider more closely than ever both the water supply and the dosage of chemical. Hence the study of the nozzle becomes of greater importance.

So far as I can learn the earliest attempts to study spray-nozzle patterns were made by Prof. French in California and by Davies, and Smith - Homewood at Wye College in England. Oddly enough both groups of investigators published their results in 1934. Prof. French developed a boom type sprayer not unlike our latest models. He also mentioned spray patterns and apparently conducted some experiments with them. One technique he mentioned is that of holding a glass slide coated with lamp-black in front of an oil spray. The size and arrangement of the drops could then be studied by use of a microscope.

The technique of the English investigators is very like the one I propose to describe to you later but can hardly be classed as simple. An arrangement similar to the focal plane shutter of a high speed camera operated between the nozzle and a sheet of paper, and patterns representing an instantaneous exposure were outlined by the use of dyed water. Control of such a large shutter is obviously difficult. All nozzles tested were apparently of the hollow cone type.

About 18 months ago our department became interested in spray patterns. The rather obvious method of driving a sprayer over sheets of paper was considered but its defects were so numerous and the technique so cumbersome that other possibilities were studied and the apparatus to be described was finally constructed.

Description of the Test Apparatus

The main frame of the test apparatus is two wooden 2" x 4"s twelve feet long on edge and spaced 18" apart. These are supported by legs about 24" high

and securely braced. On top of each of the 2 x 4 rails is fastened a length of 1" angle iron with the sharp corner up thus forming a smooth, nearly friction-less track for a small table of plywood which is supported by four fixed wheels, two grooved and two plain. These are of aluminum and the whole table assembly is kept as light as possible to decrease inertia effects. It is 18" x 24" with the 24" dimension at right angles to the track.

Fastened to the 2" x 4" are two parallel shafts one at either end of the track. These carry pulleys on which run a 2" - 3 ply rubber belt. The driving pulley is powered by a speed to produce a belt speed of 4 M. P. H. (a common speed for tractor mounted sprayers). A hook on the table can be attached to an eye in the rubber belt which is midway between the rails and at approximately the same level. It has been found a wise precaution to use a short length of weak string for attaching the table to the belt. When the motor is started the table moves along the rails and after about 7' of travel contacts a limit switch which stops the motor and usually brings the moving table to rest before it travels the remaining 5'.

To the moving table is pinned securely an 18" x 24" sheet of white paper (a cheap grade known as "Poster Paper" and costing 2 3/4 cents per sheet has been found very satisfactory) and six feet from the starting point the whole assembly passes beneath the nozzle or nozzles to be tested, these being supported by adjustable laboratory stands. By spraying the ink-water mixture from the nozzle a permanent record of the spray pattern is readily obtained.

Operation

To test a nozzle, it is first mounted at the desired height and spacing. The use of a rubber hose to connect the nozzle to the pump is advisable and an adjustable laboratory stand (as shown in the photo) greatly facilitates this part of the work. A gear pump of 1/4" pipe size driven by a 1/4 H.P. motor at 800 R.P.M. will supply adequate volume and pressure and the pressure can be kept at any desired amount by the use of a spring loaded relief valve. An accurate gauge should be mounted in the pressure line in full view of the operator. A sheet of paper is pinned to the table which is moved to the starting end and attached to the belt. The pump is started and a container held beneath the nozzle until the pressure and pattern are normal. The motor operating the long belt is then switched on and the container withdrawn from beneath the nozzle. The paper passes the nozzle receiving spray and as rapidly as possible the container is returned to catch the spray until the motor operating the pump can be stopped. Obviously the limit switch could also be adapted to stop this motor also (a refinement not yet on our original model). In practice it has been found quite easy for two operators to take a spray pattern in two minutes without automatic motor switches. The ink-water mixtures dry rapidly on poster paper and they are dry enough to handle in five minutes.

And now to describe some of the uses and some early results of this method of spray pattern study.

Obviously it is primarily a research tool and in practical field spraying the findings while enlightening have less value. However, we consider them of importance to (a) Nozzle manufacturers, (b) Those engaged in cultural experiments and plot tests and (c) Extension workers in agriculture.

The manufacturer can, we believe, test and improve his product more simply by this technique than by any other known method. One prominent nozzle maker has already obtained plans for the construction of this test equipment and there is scarcely a nozzle made on this continent on which we have not made some preliminary tests.

The field experimenter we feel should know the characteristics of the equipment he is using to apply 2,4-D to crops or weeds if he is to eliminate a possible variable in his results. We cannot say definitely that size of drop and relative distribution are a cause of variation in response to 2,4-D but believe the possibility is worthy of investigation.

The Agricultural Extension worker equipped with a set of spray patterns will have little difficulty in convincing sprayer operators of the value and need of proper methods of operation and the need for more precise control of their machines.

The following slides show some typical results of our early tests.

Slide No. 2. Shows a well distributed spray tapering off on the borders and if I were to say what lots of nozzle makers ask me to say this is probably as near the ideal as we have at present. However the real answer must be sought in the experimental plots.

Slide No. 3. Shows a somewhat similar distribution of particles but both borders contain larger particles. This was very typical of most fan nozzles sold in 1948. It is obvious that if two of these heavy borders overlap, as they usually do, the rate of application is perhaps double that at other points. On a susceptible crop like flax this could cause damage. Some of our observers claim to have noticed a striping of flax crops.

Slide No. 4. This shows a nozzle which applies about 7 gal. per acre and delivers a much coarser spray than the others.

Slides 5,6,7. These three slides in kodachrome were made to show a further development of the technique with 2 separate pumping units, one black ink, one red. Adjacent nozzles are each made to spray one half of the sheet of paper. Hence it is possible to study with ease and accuracy the variations in overlap caused by any combination of pressure, nozzle height, nozzle spacing fan angle and fan alignment. The slides shown are for height variation only with heights of 13", 16" and 19" and illustrate the simplicity of this method of study.

Slide 8. Shows the pattern from a typical knapsack sprayer.

To sum up:

(Abstract)

The need for a simple method of studying spray nozzle patterns is greatly increased by the development of the low volume nozzle and by the discovery of the herbicidal properties of 2,4-D.

A review of the work of earlier investigators indicate that their techniques for spray nozzle pattern study were rather cumbersome.

A simple technique for studying spray nozzle patterns is described and some of its possible applications are discussed.

Typical patterns are exhibited to show some of the characteristic variations of present day nozzles.

CONSIDERATION OF FACTORS IN THE APPLICATION OF HERBICIDES WITH AIRCRAFT

Mr. O. K. Heddon made some interesting and significant remarks on this topic, but had not had opportunity to obtain approval for a formal paper, hence none is included here.

INDUSTRIAL VIEWPOINT AND NEW HERBICIDES

W. C. Dutton in charge

THE INDUSTRIAL VIEWPOINT

W. C. Dutton, The Dow Chemical Co.

The program committee has asked me to talk on "The Industrial Viewpoint", and I was perplexed for some time as to just how to approach this subject. I have talked with several College and Station men, and have learned of a definite interest in how industry carries on its own research and how it supports and cooperates with public research. I shall present to you, therefore, a point of view on research and some thoughts on the problems involved in the development, introduction and sale of new products for use in agriculture.

I presume that most of you here today are interested primarily in chemicals for the control of weeds but I am going to talk on the basis of agricultural chemicals in general, which includes herbicides, fungicides, insecticides, soil fumigants, defoliants and plant growth regulators in general.

I would like to make it perfectly clear that in talking on "Industrial Viewpoint" I am neither qualified nor authorized to speak for Industry in general, but what I have to say will undoubtedly apply to many, as most producers of agricultural chemicals have similar problems.

I worked for 23 years on the staff of a state experiment station and during most of that time was studying the use of a few of what we now call agricultural chemicals. Early in that period the list of such chemicals was very small and consisted almost entirely of fungicides and insecticides, mostly inorganic compounds, but the list has grown rapidly in recent years and you may ask, "where did they come from and how were they developed." Twenty five or thirty years ago the usual procedure was for the manufacturer to send a new product to some Experiment Station worker and ask him to test it. Few manufacturers in those days had facilities for thorough development of new products. I shall try to indicate where some of the newer materials originate and how they are developed.

I think it will be well to indicate some of the steps involved in development of an agricultural chemical. The first step is to get the compound. It often comes from the laboratory of some chemical manufacturer but may be the

product of a public or private laboratory. You are all familiar with the several highly publicized compounds that were brought from Europe during recent years. In any case, it goes through more or less standardized screening tests to learn if it has any merit as a weed-killer, insecticide or fungicide. Only a very small percentage of the compounds tested show enough promise to be given further trial. If the compound is a new one there were probably only a few grams of it available for the screening tests so the next step is to get material for more extensive laboratory tests, preliminary field testing and finally extensive and widespread field tests. This all sounds rather simple and sometimes it is possible to move rapidly but the general rule is that several years of intensive work are required to get a product ready for market and it is surprising how many promising materials fall by the wayside even after several years of study. I think any research or production chemist could tell you of the many difficulties encountered in going from "test tube" sample to larger laboratory sample to pilot plant and finally to commercial production. Another step that is often difficult is getting the new product into a composition that can be handled satisfactorily by the user. Most of the older inorganic compounds were relatively easy to handle but many of the newer organics present serious problems and there is no simple rule for formulating them. It is pretty safe to say that nearly every compound requires some special wetting agent, diluent, emulsifier or solvent and packaging some of them is a real problem.

I have indicated some of the steps required for developing a new product but there still remains the question of by whom this research is done. There are several types of research organizations such as: - 1) Industry research, 2) Private laboratories and research foundations and 3) Public research groups. Industry research is normally and naturally on the problems of and primarily for the benefit of the sponsoring company. The private or consulting laboratories are organized to study, for a consideration, projects that are brought to them. By public research I refer to state agricultural experiment stations, the United States Department of Agriculture, and comparable groups in Canada. These organizations are publicly supported and their research programs are primarily for the benefit of the public in general, but there are so many variations in projects that it is not possible to sharply define them. The Federal groups work under a system that is well understood by all of you. State experiment stations operate generally under a more flexible system and there are many cooperative projects between Industry and the Agricultural Experiment Stations.

The screening of new compounds is usually done by industry itself or for industry by some private or semi-private agency but in some instances this type of work is done by or under the direction of workers in public research groups with industry support. Some station workers like this type of project but others are critical of such arrangements because they think they are not in the interest of the public in general. That, however, is a question to be decided by the administrators of each institution. There are so many variations in how the later stages of development are carried on and how problems arising from the use of new products are handled that it is impossible to make any general statements.

It seems only reasonable that Industry should in some manner carry its new products through the preliminary and intermediate stages of development up to

the point where there is a reasonably good chance of success. From that point on I believe that cooperation between Industry and public research groups is definitely to the advantage of everyone concerned including the ultimate user of agricultural chemicals. There is a notable exception to the indicated procedure of Industry carrying the early stages of development and I refer to the general custom of Industry furnishing chemicals to public research workers who are working on some special problem.

I have said that cooperation in the later stages of development are desirable for all concerned. Farmers normally and properly depend upon public institutions for recommendations on the use of agricultural chemicals and the workers in these institutions cannot advise intelligently on the use of a product until they have worked with it. On the other hand Industry is usually not in a good position to market a product until it has been evaluated by public research groups even though it has been carried to an advanced state of development by Industry. Cooperation at this stage makes it possible for Industry to get earlier approval of new products and to have them tested on more pests and under more conditions than is possible otherwise. Such cooperation enables public research workers to have advance information on and experience with new products by the time they are ready for introduction and sale. This all makes it possible for the ultimate user to get desirable products sooner and to have more reliable recommendations on their use.

There are certain products that have been carried through the early stages by public research workers but Industry must enter the picture to manufacture and distribute them. Cooperation in the development of such products is obviously essential.

Cooperation in the late stages of development takes many forms. It may consist of manufacturers simply supplying materials to Experiment Station workers and others for trial tests and this is done extensively. When Industry has one or more products for a certain use it can go to an institution that is working on that problem and give financial and other aid to supplement the means they have available. Many of such financial grants are called "grants in aid" and are usually used to hire labor and technical assistants and for travel. Many workers like very much to have these grants as they are not usually subject to as many restrictions as public funds and enable them to extend projects that would otherwise be limited.

Problems of more fundamental nature are often set up in "fellowship" arrangements which may run for one year, three years or any length of time required to solve a problem that is of mutual interest to Industry and the Public. There can be many other variations in arrangements which I do not need to discuss. There are certain rules that are pretty uniform in all articles of agreement drawn up to cover cooperative arrangements and I think Industry can offer no objection to such arrangements but it will usually shy away from long and complicated contracts that cover all sorts of conditions that probably never will occur. I once received a seven or eight page contract to cover a $200.00 project.

Some administrators of public institutions insist that the person or persons directing a cooperative project shall have the right and the duty to interpret the results obtained from the investigation in question. There should always

be a free exchange of ideas on a project but I feel that this condition is fundamental to the success of any research project. I cannot conceive of Industry giving financial aid to any individual if it did not believe that he was well qualified to carry on the work in question and to interpret the results obtained. Furthermore, I would not like to set up a project with a person whom I had reason to believe would let his interpretation of results be influenced by the fact that financial aid had been given or by pressure of any kind. If such conditions prevail the project changes from research to promotion and promotion of that kind is not a function of public research insititutions.

This brings to mind a remark that was made about me when I left Experiment Station work and went into Industry. An individual of a type that I think you can visualize said "Well, Dutton has gone commercial" with the definite inference that "Dutton had gone to the dogs." I can say very honestly that I have had no regrets for having made the change for the very good reason that I have found that the research program of Industry is just as sound and well directed as that of any public institution. We are told in our work with agricultural chemicals to "get the facts, no matter what they are or whether we like them or not". Research is the background for most sales programs and no sales program can proceed for very long if it is not on a sound basis.

I will repeat that I believe that cooperation in research with agricultural chemicals between Industry and public workers is desirable and benificial to both and is to the best interest of the public in general.

Special Problems

When I was asked to prepare this paper it was suggested that Industry might have some gripes or complaints to make. I do not care to gripe or complain about anyone or anything but there are some attitudes and conditions that affect everyone interested in agricultural chemicals that might be profitably discussed

By-products. We often hear comments about new products to the effect that they are made from some by-product that was being thrown away or burned. There undoubtedly are instances where a so-called by-product is utilized for some useful purpose but I am very sure that exactly the opposite condition is the general rule and most of the new products used as agricultural chemicals are organic compounds that have to be built up from basic materials through various stages and there are very likely to be companion products that the manufacturer may or may not be able to utilize to advantage. I am not a chemist and know little about figuring production costs but I am very sure that it is usually not possible to take a so-called by-product and utilize or market it without additional costs. If it cannot be sold or utilized it is a charge against the primary product and if it is utilized it has to stand on its merits and bear its share of costs of basic materials and manufacture.

Life span. Another consideration that is very important to the manufacturer is the "life span" of a product. There has, in the past, been a reasonably slow turnover in agricultural chemicals and under that condition it was possible for a producer to build a plant and be reasonably sure that it could be operated for a considerable period of years and thus pay for itself. The condition that

prevails now is that the life span of a product may be very short and if a manufacturer cannot utilize the equipment or plant required for its production for some other purpose he will probably be pretty cautious about making the capital investment that is necessary for its production.

Specificity. Another problem that is serious with Industry, Experiment Stations and users of agricultural chemicals is what we call "specificity". This simply means that a given compound is very specific in its action and will kill or control certain weeds, insects or diseases but not others. This can be a very desirable characteristic, especially with herbicides, provided it does not affect the plant you want to save but it doesn't always work that way. Specificity is very marked with many of the newer organic insecticides and fungicides and you all know much about this in connection with weed killers. This situation makes for a multiplicity of products for manufacturers to make and for dealers to stock, it complicates recommendations by agronomists, entomologists, pathologists and horticulturists, and confuses the user of the materials. There probably is nothing that anyone can do about it as that seems to be characteristic of the compounds that are being developed now.

Moving too fast. We all have heard many times in recent years the statement that Industry is moving too fast in the introduction of new agricultural chemicals. This probably has been true in some instances but I am sure that Industry doesn't like this fast pace any better than any one else and I am confident that Industry is no more responsible for this condition than the public in general.

Thorough trial. This problem of moving too fast raises the question of how to judge when a product has been developed and tested to the point where it is safe for manufacturers to sell and agriculturists to recommend it for use. Premature release of a product by Industry may embarrass public workers and users but I wonder how many cases there have been where a public worker has developed a procedure or material and made recommendations for its use and Industry has supplied the necessary materials only to have the whole thing backfire when it is put into extensive use. I have in mind a procedure that was developed by a public research worker, was tested for several years in widely separated areas, was recommended for use and the materials were supplied by Industry on the basis of the seemingly thorough trials. Every one involved had proceeded in good faith but serious complications developed as soon as it went into extensive use simply because, in my judgement, a set of climatic conditions developed that had not occurred during the development period. I could cite other similar instances. The point I want to emphasize is that it behooves public research workers as well as Industry to be very thorough in developing new procedures in order to be reasonably sure of safe use but this takes us back to the question of how shall we judge when a product is ready for release. Climatic factors, nutrient relations and the specificity I mentioned earlier all have a bearing on this. I would like to cite an instance where specificity could cause trouble if not discovered in the early stages of development. We were given a compound for field trial that was believed to have merit for the control of a certain insect that affects apples. We made several applications to some trees of Delicious and got promising indications on insecticidal activity and no injury of consequence so decided to use it in a rather extensive trial in an orchard of McIntosh. One application was made there and within a week at least 90 per cent of both fruit and foliage was on

the ground. Further observation showed that a few trees of Delicious and Rhode Island Greening interplanted with the McIntosh and which had been sprayed from the same tankful of material had absolutely no injury to fruit or foliage. I don't know the answer to this but it is obviously impossible for any researcher to know when he has encountered that unusual climatic condition or has used the product on the variety of plant that is sensitive to it.

Premature publicity. Another point that I am going to mention is that of premature publication of results or release of general publicity on a procedure or product. There are in both Industry and public research institutions men of all kinds, some are very conservative and others have few inhibitions on how soon they talk about what they have accomplished. The uninhibited individual in industrial research probably causes complications only in his own group because Industry usually does not publish the results of its research. Public workers, however, who release results from or make recommendations on the basis of limited experiments can cause much confusion. Users may build up unjustified hopes in what a product will accomplish and Industry is embarrassed and sometimes put to considerable inconvenience and expense to inform inquirers that it does not have the product, doesn't know anything about or is not ready to recommend it for use. I don't know of any rule for judging when it is desirable to publicize research results but it does seem logical to expect any worker to be reasonably sure of his results before he publicizes them or talks to users about them.

Home-made products. I think those of us who have worked with agricultural chemicals for sometime can recall that farmers and fruit growers used to mix or make many of the materials they used. Fruit growers used to make liquid lime-sulfur, self boiled lime-sulfur, calcium arsenate, other arsenicals, nicotine extracts, etc. and Extension Service men used to stage demonstrations on the home-mixing of fertilizers but I think you would have a hard time finding anyone now who does any of these things. There were probably two principal reasons why home-made products were used: - 1) there were no reliable commercial products available or 2) the home-made product was cheaper or at least it seemed to be cheaper. The principal reason why these practices have been discontinued is because highly standardized, uniform products are available. With the advent of modern herbicides there has been some talk of using home-made formulations, and that is the privilege of anyone who wishes to do so, but I am confident that in the long run most users will find it much more satisfactory to use the uniform, standardized products that are available.

Final remark. I would like to say in closing that I am not assuming the right to speak for Industry in general, or to suggest how any one should proceed in a research program but I am presenting a point of view that I feel recognizes the rights of Industry, public research institutions and the public in general.

SUMMARY ON 2,4,5-T (ON VEGETABLE AND FIELD CROPS), MCP, PCP, OILS AND MISCELLANEOUS NEW HERBICIDES

G. F. Warren, University of Wisconsin

The number of abstracts on these herbicides is extremely limited but an attempt will be made to point out the possible uses and limitations as indicated by the data available.

2,4,5-T (2,4,5-trichlorophenoxyacetic acid) does not appear to be quite as active an herbicide in general as 2,4-D. Control of annual and perennial weeds in both pre-emergence and post-emergence applications was at best equal to and more often poorer than the control with comparable formulations of 2,4-D. On the other hand, it showed some notable differences in selectivity on crop plants which may have practical applications. In an experiment on corn, a post-emergence spray of 2,4,5-T caused significantly less stalk bending than 2,4-D while in other experiments red and white clover were reported to be much more sensitive to 2,4,5-T. Its possible use in eradicating white clover in turf areas where it is undesirable was pointed out. Its effects on the other crop plants for which results were reported were similar to 2,4-D where used as either a pre-emergence or post-emergence spray.

MCP (2-methyl-4-chlorophenoxyacetic acid). Control of annual weeds in both pre-emergence and post-emergence sprays with MCP was practically the same as with 2,4-D. On oats, corn and alfalfa it also gave results similar to 2,4-D but the isopropyl ester of MCP caused no reduction in the stand of red clover whereas the isopropyl ester of 2,4-D in the same experiment greatly reduced it. On the other hand, MCP as a pre-emergence treatment reduced the stand of onions while 2,4-D caused no injury. These results indicate that MCP has similar activity yet may vary greatly in selectivity as compared with 2,4-D and, therefore, should warrant more attention in future investigations.

PCP (pentachlorophenol) in oil or in oil-water emulsions gave generally good control of emerged weeds and appears promising as a general contact herbicide and for pre-emergence control of weeds that come up before the crop. The sodium salt of PCP was much less effective on emerged annual grasses but gave fair control of broad-leaved weeds. The latter preparation did not reduce the yield when used on flax. Although no reports were received, it should be mentioned here that the sodium salt of PCP has been tried in several states during the past few years as a selective spray for onions. Results have been variable.

Good weed control and little or no crop injury was reported with residual pre-emergence applications of 15 to 25 lbs. per acre of PCP on several crops. Depth protection is believed to be an important factor in selectivity. Therefore, large-seeded and vegetatively-propagated crops such as beans, peas, asparagus and potatoes seem to be best adapted to this promising new method of weed control.

Oils have been widely used for many years as general contact herbicides, as selective sprays for carrots and more recently as pre-emergence sprays on vegetable crops. Therefore, they are not as a group new herbicides but new oils and new uses are continually being found.

Only a few reports were received on experiments with oils. In one, three special oils were tried as post-emergence sprays on flax with some apparent possibilities. Diesel fuel as a pre-emergence spray gave good control of emerged weeds but had no effect on either weeds or crops that had not emerged. For pre-emergence spraying of many small-seeded crops, the absence of any residual effect is often a desirable feature.

Other new herbicides. Information on these is too limited to draw any conclusions. Xanthogen disulfide gave good results while benzene hexachloride and chlordan gave poor results as pre-emergence sprays in single experiments.

REPORT ON RESULTS FROM USE OF IPC AND TCA

George L. McCall

Isopropyl-N-phenyl carbamate. The herbicidal effects of isopropyl-N-phenyl carbamate or IPC for short, were first reported by English workers. They noted that when the material was applied to the soil many of the annual grasses were prevented from establishing themselves. They also noted that IPC had a marked degree of selectivity and seemed to have little effect on many seedlings of the broad-leaved plants.

This action was the direct opposite of that of 2,4-D, which when applied as a post-emergence spray killed a large number of the broad-leaved weeds and allowed most of the grasses to continue growth. Because of this unusual selectivity of IPC considerable interest in the material was awakened and it was tested by a number of investigators.

To date results have been somewhat varied and it is rather difficult to state the exact place that IPC will fill in our herbicidal program. We can make several general statements concerning the findings to date.

(1) IPC cannot be used to control established stands of perennial grasses. It has been comparatively ineffective when applied to Johnson grass, Bermuda grass and quack grass at dosages that vary from 100-200 lbs. per acre and applied at different times during the year.

(2) IPC offers some promise for pre-emergence control of grasses in crops, but cannot be used to control established stands of annual grasses.

2 lbs. per acre permitted a good stand of red clover and gave good control of foxtail. At 20 lbs. per acre applied as a pre-emergence treatment IPC gave good weed control in soybeans with no injury to the soybeans but killed corn when applied in the same manner. When used at low rates the compound looks promising as a pre-emergence treatment for some legumes.

The chief disadvantages heretofore associated with IPC have been its very low solubility and the unavailability of suitable formulations. Satisfactory formulations are now available from a number of sources and its comparative insolubility is probably one of the greatest advantages of the compound when it is applied as a pre-emergence treatment. The chemical will usually remain in the upper surface of the soil where the vast majority of the weed seed germination will occur.

A great deal more work must be done before we can know the possibilities of this compound.

Trichloroacetic acid. The herbicidal properties of trichloroacetic acid and its ammonium and sodium salts have been under investigation for some time and there is a widespread interest in the possibilities they offer as weed control agents. The compounds have been widely tested and a number of workers have reported their results. Many of the results are in conflict and are not easily explained but there are a number of generalizations that can be made.

(1) The trichloroacetates (TCA) can be used to control some of our perennial grasses when they are considered to be weeds. These grasses include Bermuda, Johnson and quack grass. Bermuda and quack grass are controlled by rates of 80 to 100 pounds per acre of the acid and little additional benefit is received from heavier rates. Johnson grass may require rates in the neighborhood of 100 to 150 pounds per acre. Spot treatment will be required to eliminate the escape plants of all these grasses.

(2) Cactus, Opuntia sp., can be killed with the trichloroacetates. The material is applied at the rate of one-half pound per gallon to the point of run-off. A small amount of spot retreatment may be necessary.

(3) Many of the annual grasses can be controlled by applications of TCA of from 25 to 40 pounds per acre acid equivalent.

(4) Pre-emergence treatments with TCA at rates of from 2 to 50 pounds per acre have controlled most annual grasses and some broad-leaved weeds. Most of the crop plants involved in the treatments, including soybeans, corn, red clover, flax, and lima beans, showed varying degrees of injury from the treatments. Most crops were severely injured. At the present this type of treatment does not appear promising.

(5) Moisture and soil conditions have an important bearing on the effectiveness of soil applications of TCA. Rainfall is necessary to carry the material into the soil but excessive rainfall has resulted in poor control.

On light soils and under favorable moisture conditions soil applications are equal to or more effective than applications made to the tops of the plants. Applications made to the tops of the plants have usually proven more effective than soil applications if poor moisture conditions prevail and the soil is heavy. High calcium content of the soil may also affect results.

(6) The ammonium and sodium salts of trichloroacetic acid have in general given results that are equal. If an advantage exists it probably lies slightly in favor of the ammonium salt.

TCA and its salts will undoubtedly be a valuable addition to the growing list of herbicides. They will probably be available on a limited commercial scale in 1949. Much more experimental work will have to be carried out before we can definitely know the possibilities and limitations of these compounds.

REVIEW OF RESULTS FROM USE OF 2,4,5-T ON WOODY PLANTS AND METHYL BROMIDE AS A PRE-PLANTING TREATMENT

W. C. Dutton

2,4,5-T, isopropyl ester, in a water spray at a concentration of 2000 ppm applied to the foliage of poison ivy growing under apple trees gave complete top kill of all plants in shade or exposed to sunlight. Applications were made at intervals from June 16 to Aug. 25. There was no regrowth in 1948 but this will be checked in 1949. There was no evidence of injury on the apple trees involved (variety not known). 2,4,5-T has also given superior results on certain species of trees when applied to the bark or stump and can probably be indicated for use in combination with 2,4-D on species that have some tolerance to 2,4-D.

Methyl bromide applied to the soil as a pre-planting treatment gave striking results in the control of the dormant and germinating seeds of broad-leaved weeds and grasses as well as vegetative parts of plants. The treatment also controls root-knot and lesion type nematodes and soil infesting insects. The soil should be in good planting condition for best results. Very low or very high moisture content is unfavorable and the soil should be in a loose, friable condition. It is applied under a gas proof cover from small cans through a tube attached to a Jiffy applicator. Applications of 1/2, 1 and 2 lb. per 100 sq. ft. with 24 and 48 hours exposures have all given good results. Kill of seeds, plants, nematodes and insects was accomplished to a depth of 8 inches or more.

Thursday evening, December 9

ANNUAL BANQUET

At the banquet at Knights of Columbus Hall, Arnold P. Benson, Director of the Illinois State Department of Agriculture, acted as toastmaster. Very fine dinner music was furnished by the Vera Pearl Kemp Ensemble of Bloomington.

The Conference was honored in having as guests, who were introduced at the beginning of the program, the President, Bruce P. Thornton, and the Secretary, Walter A. Ball, of the Western Weed Control Conference; the President, Gilbert H. Ahlgren, of the Northeastern Weed Control Conference; the President, Clair A. Brown, of the Southern Weed Control Conference; L. W. Kephart, in charge of Weed Investigations, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Dept. of Agr.; President, T. H. Beason, Illinois Seed Dealers' Association; Leonard Condon, Condon Brothers Seedsmen; Harold Goodwin, Funk Brothers Seed Company and L. A. LaPine, Albert Dickinson Company, Henry Lunz, Agronomist, in charge of Seed & Weed Control, Department of Agriculture, Madison, Wisconsin.

Mr. Benson introduced Geo. E. Metzger, Secretary of the Illinois Agricultural Association, who gave an interesting and thought-provoking address on "The Place of a Farm Organization in a Weed Control Program". Unfortunately, he did not submit a copy of his talk.

1948 OBSERVATIONS

C. J. Willard

It has been my privilege to attend every meeting of the North Central Weed Control Conference. There is indeed a striking contrast tonight between that first meeting in Omaha where we had less than 100 total attendance, and this meeting in Springfield with 688 registered to date and, of course, many more in attendance. There were no exhibits at the Omaha meeting -- there was very little to exhibit except a few bits of research apparatus, hoes, cultivators, and a few flame throwers.

This tremendous expansion of our Conference has been coincident with the expansion in weed control itself. A new science is being born. We hope soon that this new science of weed control will compare favorably with entomology, the science of insect control, and plant pathology, the science of plant disease control, in knowledge of an ability to master the third great problem which concerns all farmers -- weeds.

1948 has been a year of almost feverishly increased activity in every form of weed control. In practical results, we can already point to greatly increased food production as a result of weed control operations. This year's hard red winter wheat crop of the Southwest did not start out a year ago to be a bumper crop. F. L. Timmons, with his years of experience in the hard winter wheat area, was pointing out almost a year ago that the 1948 crop of wheat in that area, if there were any wheat, would be extremely vulnerable to weeds. As a result of his warnings, hundreds of thousands of acres in that area were sprayed that had never been sprayed for weeds before, and in many instances this treatment of the weeds made the difference between a crop which could be harvested and one which could not be harvested. There is no way of estimating how much of the 1948 crop of hard red winter wheat was due to weed control spraying, but its contribution was certainly substantial.

When you add to that the millions of acres of small grain in the Northwest, Canada, and the far West, which produced more grain and less dockage as a result of weed spraying, to say nothing of the millions of acres of corn treated in the Corn Belt, you have at least a limited picture of the extent to which food production in 1948 has benefited by the newer weed control practices.

It was my privilege to spend three months this summer in Great Britain as an attache of the State Department in the Scientific Office of the London Embassy. My work was not specifically with weed control, but, of course, I took occasion to look up weed control work wherever I could. The English are doing excellent weed control work. Selective weed spraying or dusting is more common in Britain than in our East, not so widely used as in our West. Custom spraying is, I believe, more generally established in Britain than in our East.

I visited one custom spraying unit, Pest Control, Ltd. This company has eight branches covering rather more than two-thirds of England. Within that area they will accept contracts for insect control, plant disease control, or weed control, wherever satisfactory methods of spraying are known, and for the most part will guarantee results. We have with us at this Conference the technical officer of this organization, Mr. Greenslade, who I think deserves recognition as the man who has traveled farthest to attend this Conference.

The hormone type chemical most widely used in Britain is MCP. In general its effects are extremely similar to 2,4-D. It is more effective than 2,4-D on some weeds and less effective on others. Professor Blackman mentioned to me that MCP was much less hazardous to flax than 2,4-D -- a suggestion that should be worth our following up in trying to find a safe chemical to use on flax.

Apparently the basic reason why MCP rather than 2,4-D is used in Britain is that their manufacturers have more cresol than phenol available. MCP starts with cresol as the raw material as 2,4-D starts with phenol.

One of the outstanding results of our four-year development of the new selective herbicides has been the substitution of the idea of control of weeds for their eradication. This Conference largely had its origin four years ago in the desire of those officials who were legally charged with the eradication of noxious weeds to get together and talk over methods. These men are still legally charged with eradication, but since the new selective herbicides have shown very considerable ability to control these weeds and prevent their serious interference with crop production, neither they nor the farmers have in practice worried so much about eradication as in the past. Here again we are following in the footsteps of entomology. In the long history of economic entomology, very few insects have been completely eradicated in any area. The insects are still here and would do us untold harm were it not for our constant vigilance and efforts to keep them under control.

Perhaps at this late date it may not be embarassing to point out that much that passed for eradication before 1945 actually accomplished little more than control. One has only to think of the hard seed problem in the bindweed area to realize this. On the plots of the Department of Agronomy at the Ohio State University every patch of Canada thistle which we "eradicated" in the period from 1928 to 1935 is with us yet, in 1948.

I want to report to the Conference on one of its important committees. Those of you who attended the Des Moines meeting will remember that we had a discussion of the Research and Marketing Act or Hope-Flannagan bill at that meeting and at the business meeting a motion was made to appoint a committee to make every possible effort to direct significant amounts of Hope-Flannagan funds to weed control research. It was my fortune to be made chairman of this committee.

There are several titles in the Research and Marketing Act. Funds from that Act which are directly appropriated to the United States Department of Agriculture are already being used by them for weed control research in several states. However, our committee was particularly interested in obtaining funds from that title of the bill which provides funds to the States for cooperative research. By the time of our meeting the available funds had already been tied up until July 1, 1948, without providing for weed control research. Congress in 1948 did not appropriate the full amount of funds called for by the original Act and as a consequence no funds for new projects will be available at least until July 1, 1949.

To obtain these funds, if and when they became available, it was necessary to submit a project and your committee gave its attention to the preparation of a cooperative weed control project in the North Central region. As a result

of this activity a regional technical committee on weed control was organized a year ago, one member from each state being appointed by the Director of the Experiment Station in that state. After preparing a tentative project by mail, based on the one prepared by our committee, this committee met in Chicago in July, 1948, and prepared a project on cooperative weed control which was submitted to the Directors of the North Central Stations at their meeting in August, 1948. The Directors thought very well of this project and voted to put it in second priority for any additional funds which become available July 1, 1949. Our favorable position in this regard is largely due to the initiative of this Conference in its original action.

A characteristic of the new organic weed killers is their amazing specificity. Mr. Dutton in his talk on new chemicals this afternoon alluded to this property and the difficulties which it makes for the manufacturer. It also leads us to believe that we can ultimately develop chemicals to do almost anything that we wish. We will use chemical A to take weed M out of crop X, chemical B to take weed R out of crop Y, and chemical C to take weed R out of crop Z. Obviously, when and if we can do this, the crops and weeds must present a sufficiently extensive problem to justify the manufacture of the chemical, or it will not be made. Even with that restriction the increasing number of chemicals will necessarily be an increasing headache to the manufacturer.

Furthermore, this increasing complexity means an increasing demand for specialists. Those of you who have listened to the programs of the past two days will not need to be convinced that it is not possible to put down simple, accurate directions for the safe use of these chemicals. They are powerful agents which can easily do harm and the likelihood that they will do harm depends upon complex factors concerning the soil type, crop, weed, weather, etc., which it is nearly impossible to put into a set of directions which a novice can follow.

If competent men take it up, therefore, this is more and more a field for custom sprayers. Every custom spray company that is to survive must have a man or men whose business is not putting on spray, but in knowing where, when, and what to put on in a given situation. Organizations that develop and become known for such service will grow and prosper in years to come.

This is my final appearance as President of the North Central Weed Control Conference. I have enjoyed the work and appreciate the honor beyond my power to express. I am sure that the North Central Weed Control Conference will go on to greater and greater heights as a leader in this new science of weed control.

REMARKS PRESENTING L. W. KEPHART

C. J. Willard

This is the first time that the North Central Weed Control Conference has taken advantage of the provision in the constitution providing for honorary membership. I cannot think of a more suitable choice for our first honorary member than Mr. L. W. Kephart, Senior Agronomist in Charge of Weed Investigations of the Bureau of Plant Industry, Soils, and Agricultural Engineering of

the United States Department of Agriculture.

Mr. Kephart has long been associated with the North Central Weed Control Conference. His was the outstanding talk at the organization meeting of the Conference at Omaha four years ago. He has attended our meetings and worked with our personnel consistently since.

Mr. Kephart is no Johnny-come-lately in weed control work. He joined the staff of the Bureau of Plant Industry in 1913 as a weed control specialist, and has been more or less in that field ever since. He was shifted to Forage Crops, especially sweetclover, for a while, but he never dropped weed work entirely.

The Congressional bindweed appropriation in 1935 finally again gave Kephart a full-time weed control program, and he has continued with it until now. We all know more or less of what he has done to help the present vastly increased program of weed control.

I should like to read this citation:

TO LEONARD W. KEPHART

In recognition of notable contributions made to progress in weed control research; for long association with and interest in weed control work; for competence in scientific skills; for unflagging devotion to service; and for his spirit of cooperation, all of which have set a high example for other workers in this field of agricultural research, the North Central States Weed Control Conference presents this scroll on the 9th day of December, 1943.

Mr. Kephart, it is with the greatest personal, professional, and presidential pleasure that I present you this scroll.

REMARKS ACCEPTING HONORARY MEMBERSHIP

L. W. Kephart

Dr. Willard, and, I may now say, Fellow Members:

It is customary at a time like this, when a person is being accorded an unusual honor, and this certainly is such an occasion, for the recipient of the honor to rise unsteadily to his feet and in a shaking voice explain that he is taken entirely by surprise and is at a complete loss for words. Unfortunately I cannot claim that I am taken by surprise because Dr. Willard notified me three weeks or more ago that I had been elected an honorary member of this Conference and he asked that I be here tonight to receive this scroll. Furthermore I am sure that none of those who know me well would agree that I am ever at a loss for a few thousand assorted words. Consequently I might be expected to make a few cool and rational remarks. This I will try to do. Nevertheless a person would be a wooden Indian if he did not feel a constriction of the throat and a tightening of the heartstrings upon listening, as I have just done, to such felicitous words from an old friend. A man would be less than human if he did not feel pride at such commendation and gratitude toward those

who made such a moment possible. I hope, therefore, that you will accept these words as an expression of the most sincere appreciation of the friendly feeling implicit in the presentation of this scroll.

In the fear that I might become maudlin about this perhaps I had better confine myself to some of the lighter elements in Dr. Willard's remarks. He has alluded to the early days of the North Central Weed Control Conference and he has accused me, at least by inference, of, shall we say, unplanned fatherhood in that connection. It seems, therefore, to be a good time to record for history the precise facts as to the origin of this conference. It is appropriate that we should discuss the matter while here at the home of Abraham Lincoln in Springfield, Illinois, for the North Central Weed Control Conference, like Lincoln, was of humble origin. It was brought into being, in fact, in the mud. It began, as I recall, on a cold rainy day in late October, 1942, on a farm somewhere in eastern Kansas. For several days a number of us had been traveling with Ted Yost on one of his breakneck field trips examining trial plots of chemical weed killers. Late on that dismal afternoon we came to the last series of tests. As luck would have it these plots were located not along the highway but way out in the middle of a 160 acre field. The field had recently been plowed and was, to put it mildly, a sea of mud. Ted with his usual vigor started wading across that field as though the mud did not exist. The others followed in his footsteps, with your humble servant bringing up the rear. I was wearing, as it happened, low shoes and rubbers. Before I had gone thirty feet into that sticky goo both rubbers and shoes were sucked off and I was left plowing through the icy muck in my socks. Finally we arrived at the middle of the field and there while I stood virtually bare-footed in ankle-deep mud in a downpour of frigid rain the North Central Weed Control Conference was born.

The conference has come a long way since that day. I am certain that none of us who were in at the beginning had the faintest notion that the conference would reach its present size and influence. I doubt if Harry Truman himself could have forecast that outcome. Yet here we are 700 strong and the nucleus around which a multi-million dollar business has been built. The question now is where do we go from here. Actually I wonder sometimes where we are. As I sat here this evening I have been wondering why all of you men are here. Did the commercial men come in a desperate effort to obtain orders in an over-expanded market or are they here to spend some of their fabulous profits before the income tax man gets to them? Are the official people here because they do know something about weed control, or because they do not?

Perhaps the safest thing is to say that we are all here because we are trying to bring order out of a somewhat bewildering confusion. In that case I hope that all will take heart for the confusion, I am certain, is more apparent than real. If you doubt that think back two or three years and see whether we have not come a long way since that day in Omaha when this conference was first organized. If we seem to be making progress slowly remember that this is an infant science, a mewling child only four or five years of age. How can we expect to have all the answers now. Look at entomology and plant pathology to mention only two. Think of the hundreds, even thousands of people who have been working in those fields for fifty or sixty years or more, and think of the number of unsolved problems that still confront those groups. Considered on that basis we may well feel proud rather than disheartened.

Dr. Willard has just pointed out the discrepancy in numbers between those working in weed control and those working in other agricultural fields of perhaps even less economic importance. I would go farther and say that if I were a young man looking for a career I would look long and seriously at the possibilities in the field of weed control. If you ask what these possibilities are I point again to the field of entomology. How many of the men now in weed investigations have begun to specialize on narrow aspects of the subject? Virtually none. But look at the degree to which specialization has been carried in other agricultural sciences. I know an entomologist who has made a lifetime career out of one bug. Not only does he devote his entire time to one bug, he uses only one chemical on that bug. Not satisfied with that he confined his investigations to the limits of a single county. Indeed the last time I saw him he was not only staying in the county he was staying on his own premises. So now he has consecrated his life to one chemical on one bug in one county in his own backyard. Certainly we have a long way to go in weed research before we reach that degree of specialization and there should be lots of jobs available in between.

Dr. Willard has called attention too to the high degree of technical skill shown by workers in weed control in England. As he well points out England is a small country compared to the United States and the problems there are less complex. Here the problems are enormously diversified and in the rush to obtain answers for even part of these we have not had time to devote ourselves adequately to the intimate details of technical weed research. However, that time is coming and it is altogether likely that within a few years our young weed men will be working with scientific precision comparable to that in any other field of applied natural science.

It is because I believe this, because I see this group as the progenitors of a large and honorable profession that I feel it a real distinction to be elected an honorary member of this Conference. I am proud to have been among those who had a hand in its beginning.

In accepting membership in this Conference I pledge myself to the furtherance of its interests, and I wish and truely believe that it will have a long, harmonious, and useful life.

The place and date of the 1949 Conference, Sioux Falls, S. D., December 6, 7, and 8, were then announced, and the new officers, R. S. Dunham, President, Glenn Viehmeyer, Vice-President, and E. A. Helgeson, Secretary-Treasurer, presented to the Conference.

Friday, December 10

Centennial Building Auditorium

SECTION I - PHYSIOLOGY AND BASIC STUDIES

George McNew, Chairman

EFFECT OF SEVERAL HERBICIDES ON GERMINATION OF SUGAR BEET SEED

Charles R. Swanson 1/

Recent interest in pre-emergence treatment to control weeds, in which the herbicides are applied before germination or emergence of the crop, creates a necessity for knowledge of the physiological effects of the chemicals in use on germinating seed. Seeds exhibit many of the processes occurring in mature plants. Thus if a certain chemical depresses or accelerates the metabolic activities of a mature plant it is likely that the effect upon the seed of the same species will be very similar. In this way testing the action of a chemical in question by the relatively rapid and convenient method of treating the seed could serve well as a preliminary screening test for possible herbicides.

In these experiments sheared sugar beet seed was subjected to treatment with the sodium salt of 2,4-dichlorophenoxyacetic acid (2,4-D), ammonium trichloroacetate (TCA), and ammonium dinitro ortho secondary butyl phenol (Sinox W). Each chemical was used in concentrations of 0, 25, 100, 250, 500, 1000, 2000 and 4000 parts per million. The seeds were first washed for 4½ hours in running tap water and counted into lots of 100 seeds each. Duplicate Petri dishes containing 100 seeds each were set up for each of the eight concentrations. The seeds were placed in the Petri dishes between two filter papers impregnated with 5 ml. of chemical of the appropriate concentration and transferred to a germinator maintained at 25 ± 2° C. Germination counts were taken at designated intervals until the fourth day when the roots were measured and the seedlings discarded. In these experiments seeds were regarded as having germinated when any seedling organ had attained a length of not less than 1.5 mm. By using Taylor's (3) criterion, germinated seeds were readily observed by inspection of the Petri dishes.

The effects of the three chemicals on root length are shown in table 1. Each figure in the table represents measurements on three repetitions of the experiment or measurements on lots of 600 seeds. 200 seed controls were run with each trial, in which the root length averaged slightly more than 15mm.

In the trials with 2,4-D a decrease in root length to 33.3 percent of the control was noted at 25 ppm., the lowest concentration used. Root length decreased progressively but gradually with increasing concentration with 4000 ppm. being only slightly more inhibitory than the lowest concentration for those

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1/ Agent, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, and North Dakota Agricultural Experiment Station.

seeds that successfully germinated. A high percentage of marked clubbing of the root tips was noted at 25 ppm. Although clubbing occurred throughout the complete range of concentrations, it was most severe at 25 ppm.

Ready and Grant (2) found the roots of germinating cucumber seed to be extremely sensitive to minute amounts of 2,4-D. In their experiments concentrations as low as 0.005 ppm. produced inhibition of root growth to a statistically significant degree. Although the concentrations in the present work were taken only as low as 25 ppm., the sharp drop in root length would seem to indicate a reaction for sugar beet seed similar to that of cucumber seed.

The effects of Sinox W on germination of sugar beet seed were somewhat similar to those of 2,4-D with some notable exceptions. At 25 ppm. root length averaged 84.2% of the control for Sinox as opposed to 33.3% for 2,4-D. In Sinox-treated seed the root length was greater than that of seeds treated with 2,4-D until well over 500 ppm. at which point the Sinox-treated seedlings showed root lengths considerably less than those treated with 2,4-D. No clubbing or other malformation was noted on roots of seeds treated with Sinox at any of the concentrations. There was a definite discoloration on the majority of the seedlings.

Ammonium TCA, a relatively new herbicide which is being used for grass weed control, had a very different type of reaction on the germinating sugar beet seed. At 25 ppm. the root length averaged 102% of the control at 100 ppm. 104.4%, at 250 ppm. 108.8% and at 500 ppm. 103%. Beyond this point root length decreased gradually with increasing concentration and reached its lowest point of 74.8% of the control at 4000 ppm. No clubbing, other malformation or discoloration was evident on the roots of seedlings treated with TCA.

Table 2 shows the effects of TCA on the rate of germination of sugar beet seed. Germination counts were first made 17 hours after treatment and three times daily thereafter. The data are given in table 2 and show that there was very little difference in the rate of germination for all concentrations. Only 4000 ppm. shows a definite retardation. The stimulatory effect of TCA is not so evident for rate of germination studies as for the root length trials mentioned previously. It may be seen, however, that the lower concentrations maintained a slight lead over the control for the course of the 4 days.

Rate of germination studies on sugar beet seed treated with Sinox W showed definite retardation with increasing concentration. For example it may be noted that it took the control approximately 29 hours to reach 20% germination, 25 ppm. required 31½ hours, 100 ppm. 32 hours, 250 ppm. 35 hours, 500 ppm. 42 hours, 1000 ppm. 62 hours, and 2000 and 4000 ppm. did not reach 20% germination during the course of the experiment. Table 3 gives the numerical data.

The results of experiments on rate of germination of sugar beet seed treated with 2,4-D are given in table 4. Considering the 20% germination level it may be seen that the control required 25 hours to reach this point, 25 ppm. 26 hours, 100 ppm. 29 hours, 250 and 500 ppm. 32 hours, 1000 ppm. 34 hours, 2000 ppm. 37 hours, and 4000 ppm. 46 hours. In comparing the results of this trial with that of Sinox W it is evident that even the higher concentrations of 2,4-D were not as effective in retarding germination as was Sinox.

In their article on the effects of 2,4-D on seed germination and respiration, Hsueh and Lou (1) found an accelerated germination of barley seed at concentrations of 35 and 70 ppm. In the present investigations on the more sensitive sugar beet seed no acceleration was noted even at the comparatively low concentration of 25 ppm.

In summary, 2,4-D and Sinox W acted to reduce the rate of germination and subsequent growth to a marked degree. TCA caused stimulation of root growth and a slight acceleration in the rate of germination at lower concentrations. From these experiments it would appear that 2,4-D and Sinox W are of questionable value for pre-emergence weed control in sugar beets. TCA would seem to be satisfactory at least as far as its effect on the sugar beet is concerned.

References

(1) Hsueh, Y. L. and Lou, C. H.
1947. Effect of 2,4-D on seed germination and respiration. Science 105:283-287.

(2) Ready, D. and Grand, V. Q.
1947. A rapid sensitive method for determinations of low concentrations of 2,4-dichlorophenoxyacetic Acid in aqueous solution. Bot. Gaz. 109:39-44.

(3) Taylor, D. L.
1942. Influence of oxygen tension on respiration, fermentation, and growth in wheat and rice. Amer. Jour. Bot. 29:721-738.

Table 1. Effect of several concentrations of three herbicidal chemicals on root length of sugar beet seedlings.

Concentration (ppm)	Average root length (per cent of control)		
	Na 2,4-D	*Dinitro	†TCA
0	100.0%	100.0%	100.0%
25	33.3	84.2	102.0
100	28.6	61.7	104.4
250	24.9	39.2	108.8
500	24.0	26.4	103.0
1000	23.0	16.9	96.6
2000	20.0	14.0	87.7
4000	19.9	12.8	74.8

*Ammonium dinitro ortho secondary butyl phenol (Sinox W)
†Ammonium trichloroacetate

Table 2. Effect of ammonium trichloroacetate on rate of germination of sugar beet seed.

Concentration (ppm.)	Percent germination at given time intervals					
	17 hrs.	22 hrs.	26 hrs.	41 hrs.	46 hrs.	65 hrs.
0	2.5%	10.5%	18.0%	60.8%	67.3%	72.8%
25	4.0	8.3	16.5	62.3	71.3	76.0
100	5.8	12.3	19.0	60.5	68.5	74.0
250	2.5	8.8	17.5	57.3	67.3	70.8
500	4.8	12.8	22.8	58.3	66.5	74.3
1000	1.8	7.3	17.3	56.0	66.5	75.0
2000	2.0	6.8	13.0	53.3	63.8	72.8
4000	1.8	5.3	12.0	43.3	55.5	69.3

Table 3. Effect of Sinox W on rate of germination of sugar beet seed.

Concentration (ppm.)	Percent germination at given time intervals						
	17 hrs.	22 hrs.	25.5 hrs.	41 hrs.	46 hrs.	49.5 hrs.	65 hrs.
0	3.3%	6.8%	12.0%	51.5%	61.3%	63.3%	70.0%
25	3.0	5.3	9.0	45.5	57.3	62.0	73.3
100	0.3	3.0	7.0	45.8	51.0	57.3	67.0
250	0.8	1.8	2.8	34.3	44.0	50.0	65.0
500	0.0	0.3	1.5	17.8	26.0	33.0	53.3
1000	0.0	0.3	0.3	5.5	7.0	9.8	22.0
2000	0.0	0.0	0.0	2.0	2.3	2.5	5.8
4000	0.0	0.0	0.0	1.0	1.0	1.8	2.0

Table 4. Effect of Na 2,4-D on rate of germination of sugar beet seed.

Concentration (ppm.)	Percent germination at given time intervals						
	17 hrs.	22 hrs.	25 hrs.	41 hrs.	46 hrs.	49 hrs.	65 hrs.
0	5.8%	13.8%	20.0%	58.3%	65.0%	68.3%	73.3%
25	3.8	11.0	18.0	52.8	57.5	62.5	70.8
100	3.5	7.5	10.5	52.8	62.5	63.0	69.0
250	3.3	4.0	8.0	41.0	51.5	56.8	66.5
500	1.5	4.3	7.5	45.3	56.3	60.8	72.5
1000	1.3	3.0	6.0	31.8	44.8	51.3	59.8
2000	1.3	1.8	2.5	26.3	43.3	50.3	69.0
4000	1.0	1.5	1.8	11.3	19.0	29.3	45.8

PHYSIOLOGICAL RESEARCH ON WEED CONTROL AT THE U. S. PLANT INDUSTRY STATION

John W. Mitchell[1] and Paul J. Linder[2]

At the Plant Industry Station we have a project that is concerned with physiological problems related to the use of herbicides. Work in this project has dealt mainly with the question of how 2,4-D is absorbed and translocated by plants. In addition, the effects of 2,4-D and related phenoxy compounds on the chemical composition of wheat seeds is being studied. The way 2,4-D affects the different physiological processes in plants is also being studied in an attempt to learn why plants die when this chemical is applied to them. Results of our work on absorption, translocation, and chemical composition are reported here.

Absorption and Translocation

All of us are interested in the question of how 2,4-D is absorbed by plants and how it is translocated once it is within the plant. Let us first consider the absorption of this compound. As you know, 2,4-D is readily taken up by almost any part of the plant. It is readily absorbed by roots, stems, and leaves. Recently we have attempted to learn what part of the plant must be treated with 2,4-D in order to obtain the greatest over-all effect. Linder and others compared the effectiveness of 2,4-D when applied in equal amounts to the roots, leaves, buds, and to different regions of the stems of test plants. Summarized, the results show that the chemical was most effective when applied to young, rapidly growing parts of the stems. It was much less effective when placed on older, more mature parts of stems, and it was also less effective when applied to full-grown leaves. 2,4-D was relatively ineffective when applied to partially expanded leaves or to buds. An amount of 2,4-D sufficient to kill plants when applied to the above-ground parts, was dissolved in enough water to soak the soil around the roots. Applied in this manner, the quantity of 2,4-D used had very little effect.

From these experiments it is concluded that the chemical had the greatest toxic effect when applied to relatively immature parts of stems.

In spraying weeds, much of the chemical strikes the leaves. Young stems of weeds may be protected by leaves of the plant so that it is sometimes difficult to obtain good coverage of growing stems. Information regarding the absorption and translocation of 2,4-D by leaves is, therefore, of importance. Not only must leaves absorb 2,4-D but they must translocate it to the stem, buds, and roots before the maximum effect of the chemical is obtained.

When do leaves absorb and translocate 2,4-D most readily? It was found that leaves of test plants low in readily available carbohydrates did not translocate 2,4-D as rapidly as did leaves that were relatively high in carbohydrates.

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For instance, the ability of leaves to translocate 2,4-D to the stems was found to be related to the amount of sugar the leaves contained. In studying this relationship, the sugar content of snap bean leaves was found to drop during the night to about 2% of their dry weight. Leaves that contained this amount of sugar were not able to translocate 2,4-D to the stems. Upon receiving natural light for 1 hour, the sugar content of the leaves increased to about 2.7% of their dry weight or by about 35%. They then translocated a sufficient amount of 2,4-D to the stems to cause a mild response. When illuminated for 3 hours, their sugar content increased by about 80%, and with this amount of sugar the leaves translocated 2,4-D to the stems very readily.

It is concluded that the translocation of the growth regulator was associated with the movement of sugar or some other photosynthate. As the sugar content of the leaves increased and reached a concentration at which it was being actively moved to the stems, then the growth regulator was also translocated in the same direction.

This relationship between the amount of carbohydrate in a leaf and movement of the chemical to other parts of the plant holds when other forms of 2,4-D are used, when large amounts are applied, or if 2,4-D is applied in different carriers. In these tests the following phenoxy compounds were used: 2,4-dichlorophenoxyacetic acid, butyl 2,4-dichlorophenoxyacetate, n-octyl 2,4-dichlorophenoxyacetate, octadecyl 2,4-dichlorophenoxyacetate, butyl ester of 2,4,5-trichlorophenoxyacetate, and ammonium 2,4-dichlorophenoxyacetate. 2,4-D acid was dissolved in 95% ethyl alcohol and also dispersed in water, the ammonium salt of 2,4-D in water, and the butyl ester of 2,4-D in three separate carriers, kerosene, Varsol, and motor oil.

A measured amount of each preparation containing 200 micrograms of the chemical was applied to one leaf of each bean test plant. Lanolin was used to enclose the treated portion of leaves and thus prevent spreading of the various preparations used. The translocation of 2,4-D from a leaf to the stem was indicated by definite stem curvatures that developed under conditions favorable to movement of the chemical.

The results indicate that 2,4-D in all preparations tested was readily translocated from leaves under conditions favorable for the synthesis and the translocation of carbohydrates from the leaves. The number of carbon atoms in the ester side chains did not influence the relationship between the translocation of the stimulus and the movement of photosynthate.

All of the different forms of 2,4-D were translocated in a common manner from the leaves of test plants and the mechanizm of translocation directly or indirectly involved the translocation of carbohydrate or other photosynthate from the leaves.

Treated bean leaves retained their ability to absorb and translocate 2,4-D over a period of several days--even when translocation of the chemical was checked because of insufficient light. Treated leaves failed to translocate 2,4-D when in darkness, but they readily translocated the chemical to stems of the plants when illuminated 3 days later.

The relationship between the translocation of the growth regulating substances used and the translocation of photosynthate was not influenced by varying, over a wide range, the amounts of the chemicals applied (10 to 200 micrograms). In some instances the amount of 2,4-D acid used was sufficient to kill leaf tissues to which it was applied. Even with these relatively large amounts the movement of 2,4-D was closely associated with the translocation of carbohydrates from the leaves.

Results of these experiments indicate that 2,4-D was not moved from treated leaves that were low in sugar regardless of whether the growth regulator was mixed with alcohol, kerosene, Varsol or motor oil.

When applied to relatively mature leaves then, the growth regulator apparently moves in the same direction that sugar is translocated. It might, therefore, be expected that very young, rapidly expanding leaves would not translocate the stimulus to the stem for in these leaves the flow of carbohydrates and other compounds is largely toward the leaf--rather than away from it.

To be sure, the very young leaves of test plants were not able to translocate 2,4-D to the stems of the plants.

All of these results indicate that 2,4-D was translocated through leaf blades and petioles of bean plants in the direction of, and concurrent with the translocation of photosynthate.

Not only is 2,4-D absorbed by roots, stems and leaves, but fruits of some kinds of succulent plants absorb phenoxy compounds when these are applied to them. This has been demonstrated with 2,4-D by Pridham and in our laboratory with a closely related compound, 4-chlorophenoxyacetic acid. Seeds collected from bean pods that were dipped, when about 3/4 grown and still attached, into a water mixture containing 0.1% of 4-chlorophenoxyacetic acid failed to germinate when planted. These results indicate that this chemical was absorbed by the pods and translocated to the seeds--an effect that might in some ways prove useful in controlling the population of certain kinds of weeds.

Some interest has been shown in the use of 2,4-D as a pre-emergence treatment of crop plantings. It is necessary that we understand as much as possible about how this chemical is absorbed by seeds, when seeds are most sensitive to it, and how different kinds of seeds and seedlings are affected by 2,4-D. We are now attempting to determine if 2,4-D is absorbed by resting or dormant seeds, or if some kinds of seeds are relatively insensitive to the chemical until after their seed coats have broken and germination has started.

Seeds of subterranean clover remain dormant when kept in soil at relatively high temperatures but germinate readily when the temperature of the soil is reduced. Seeds of this kind were sown in warm moist soil containing 2,4-D at the rate of 4 pounds per acre and in cool moist soil containing the same amount of the chemical. Those in the cool soil germinated but soon died. After several weeks, when the 2,4-D in the warm soil had had time enough to become inactivated, the temperature of these plantings was lowered. The seeds then germinated and the plants grew normally as though no 2,4-D had ever been added

to the soil. Dormant subterranean clover seeds are apparently not sensitive to the chemical even after they have absorbed an optimum amount of water for germination. The chemical apparently is not absorbed by these seeds until the seed coat is broken.

In other experiments mustard seeds in different stages of germination were treated with 2,4-D, then were washed free of the chemical. Unsoaked seeds were relatively resistant to 2,4-D while those that had taken up water and swollen were more sensitive. Once the seed coats had cracked open, the seeds became extremely sensitive to the chemical. Apparently mustard seeds are affected by 2,4-D to some extent even before the seed coats break open.

More recently an experimental method of using activated charcoal to remove 2,4-D from seeds has been developed and it is hoped that a more thorough understanding of the effect of 2,4-D on seeds can now be obtained.

Radioactive Tracers

Radioactive elements offer a means of measuring the rate of absorption and translocation of plant growth regulators.

Radioactive 2-iodo-3-nitrobenzoic acid has already been made and used to compare the rates at which a grass and a broad-leaved plant absorb this compound. Of the two, the broad-leaved plant absorbed the chemical most readily. It was found, however, that when the leaves of both kinds of plants contained an equal concentration of the chemical, then growth of the broad-leaved plant was reduced by about 80% while that of the grass was not affected. Obviously, in this case at least, the difference in the ability of these plants to absorb the chemical did not explain the difference in sensitivity.

This first radioactive growth regulator used was one of the benzoic acid type. To answer why grasses are relatively resistant or why one species reacts to 2,4-D while another does not, we will have to look deeper into the mechanism involved when the chemical is absorbed and reacts with constituents of these various kinds of plants. To do this we need radioactive 2,4-D, which thus far has not been made. We are working toward the synthesis of radioactive 2,4-D but is a difficult task. In the mean time chemists have already synthesized a new growth regulator containing iodine which is closely related to 2,4-D. It is 2,4-dichloro-5-iodo-phenoxyacetic acid. This compound has proven to be an active plant growth regulator when used in 12 different forms, including various salts, esters, and amines as well as the acid. Equipment has been set up for making the various forms of this compound radioactive so that they can be used to further our work on absorption and translocation.

Effect of 2,4-D on Chemical Composition of Plants

It has long been known that growth regulators, such as 2,4-D and others, alter the chemical composition of plants when applied to such ones as snap bean, tomato, morning-glory, and dandelion. The soluble nitrogen in stems of test plants has for instance been increased to 8 times that of similar parts of untreated plants through the use of naphthaleneacetic acid. The amount of phosphorus, magnesium, potassium, and iron in treated parts of stems increased a significant amount within a few hours following the application of indoleacetic acid. Just

recently, much attention has been directed toward the effect of 2,4-D on the protein content of wheat. Experiments have been initiated at Beltsville for the purpose of studying in detail the growth responses of treated wheat plants as related to the protein content of the grain that they produce. In the first experiment 3 compounds were used, 2,4-dichlorophenoxyacetamide, 2,4-D acid, and 4-chlorophenoxyacetic acid. Two concentrations of each chemical were used, 0.02 and 0.1 percent water mixtures. Two varieties, Federation and Pilot, were used, and there were 6 replications of each treatment. The plants were sprayed at the time of pollination in an attempt to obtain the maximum effect. Experiments were conducted in the greenhouse.

All treatments effectively increased the protein content of Pilot, the increase varying from 1.2 to 2.3 percentage points over corresponding untreated plants. In all treatments except one, the yield of Pilot wheat was reduced. Federation variety responded, in a similar manner but to a lesser degree.

From these preliminary experiments it is evident that wheat varieties may vary with respect to the effect of 2,4-D on the protein content of grain they produce. The net effect of 2,4-D on the amount of protein produced by wheat will probably vary greatly under field conditions, depending partly upon the elimination of weed competition, which tends to increase yield, and partly upon the inhibiting effect of the chemical on the growth of the grain, which tends to reduce yield and at the same time increase protein content.

Effect of Phenoxy Compounds on Yield and Protein Content of Wheat

Treatment	Variety Pilot		Variety Federation	
	Decreased Yield	Increased Protein	Decreased Yield	Increased Protein
	Pct.	Pct.	Pct.	Pct.
2,4 D amide 200 p.p.m.	16.9*	1.4**	6.6	1.9*
2,4 D amide 1000 p.p.m.	28.8**	2.3**	3.9	1.6*
2,4 D acid 200 p.p.m.	8.5	1.4**	0.0	1.1
2,4 D acid 1000 p.p.m.	23.7**	1.8**	11.0	2.3*
4 chloro acid 200 p.p.m.	13.5*	1.2*	+4.0	.6
4 chloro acid 1000 p.p.m.	15.3*	1.3**	+5.3	.5

*Significant at 5% level
**Significant at 1% level

SURFACE TENSION AND SYNERGISM IN 2,4-D SPRAYS

David W. Stanniforth and W. E. Loomis, Iowa State College

(This paper will be published elsewhere)

THE GROWTH REGULANT, HERBICIDAL, AND PHYSICAL PROPERTIES OF CHEMICALS RELATED TO 2,4-D

George L. McNew and Otto L. Hoffman, Iowa State College

(This paper will be published elsewhere)

SOME EFFECTS OF HERBICIDAL OILS ON THE PHYSIOLOGY OF PLANTS

Wm. Harold Minshall and V. A. Helson,
Dominion Department of Agriculture, Ottawa, Canada

Certain oil fractions are being used extensively to control weeds in crops of carrots and parsnips. As yet, however, the mechanism of the selective action of the oils when applied to such crops has not been determined. The literature contains suggested explanations of this selective action of the oils but little or no experimental evidence has been put forth in support of these explanations.

In an effort to obtain information on the mechanism of selective action of oils, investigations were initiated at Ottawa to study the effect of herbicidal oils on the physiology of umbelliferous crop plants and some of the weeds commonly associated with these crops. By means of an infra-red absorption apparatus we have studied the time course of photosynthesis, transpiration, and respiration for leaves of carrot, parsnip, common mustard, lambsquarters, and common chickweed following the application of a petroleum naphtha (boiling range 300-400°F.) Some of the results that have been obtained are illustrated in the following set of slides.

Slide 1 - <u>The immediate effect of a petroleum naphtha on the photosynthesis of a mustard leaf.</u>

y-axis is the galvanometer deflection in cms.
x-axis is the time, in minutes, at which readings were taken.

"Apparatus"--the dotted line labelled "apparatus" on the slide represents the delay or lag in measuring a change of air in the leaf chamber. The construction of the apparatus is such that a change in the carbon dioxide content of the air in the leaf chamber does not produce an immediate response on the measuring device. Before a determination can be obtained for the changed air in the leaf chamber it is necessary first, for the air to pass from the leaf chamber to the absorption tube and second, for this air to displace that which is already in the absorption tube. This delay is called apparatus lag. The lower broad arrow on the slide denotes the time at which the leaf chamber was switched out in order to determine this apparatus lag.

"Leaf"--the solid line labelled "leaf" on the slide represents the photosynthesis of a single attached mustard leaf sprayed with a petroleum naphtha. Treatment was made with the leaf in the apparatus leaf chamber and the apparatus in operation. The upper broad arrow on the slide denotes the time of application of the oil. Galvanometer readings were taken at ten-second intervals.

Results: Photosynthesis of the leaf follows closely the apparatus lag. This signifies that photosynthesis ceased abruptly and completely on application of the oil. The fact that the line for photosynthesis crosses over the line for the apparatus lag signifies that respiration was being measured for this particular leaf.

Slide 2 - The immediate effect of a petroleum naphtha on the photosynthesis of a parsnip leaf.

The y-axis, x-axis, apparatus lag and treatment for this slide are the same as for slide number 1.

Results: The photosynthesis of the leaf follows closely the apparatus lag signifying that photosynthesis of the parsnip leaf also ceased abruptly and completely on application of the oil.

When the petroleum naphtha has been applied to attached leaves of carrot, lambsquarter, or common chickweed similar results have been obtained as for those just shown for leaves of mustard and parsnip. Their photosynthesis also ceased abruptly and completely on application of the oil.

Slide 3 - The effect of a petroleum naphtha on the photosynthesis and respiration of a parsnip leaf.

y axis is the galvanometer deflection in cms.
x-axis is the time, in hours, at which readings were taken.

Treatment--a single attached parsnip leaf was placed in the leaf chamber and readings were taken until maximum photosynthesis was reached. The leaf was then removed from the chamber, plunged into the oil and held there for four seconds. It was then removed from the oil, the excess oil blotted off, and the leaf was replaced in the leaf chamber. The arrow denotes the time at which the leaf was immersed in the oil.

Results: For the parsnip leaf true photosynthesis dropped to zero immediately after immersion into the oil. True photosynthesis had started to recover within 30 minutes, however, and was almost one-third of the original rate at the end of three hours. The photosynthetic rate of parsnip continued to increase until at the end of 48 hours, it was approaching normal. There was no indication of any significant change in the rate of respiration of the parsnip leaf after the treatment with oil.

Slide 4 - The effect of a petroleum naphtha on the photosynthesis and respiration of a mustard leaf.

The y-axis, x-axis, and treatment for this slide are the same as for slide number 3.

Results: For the mustard leaf true photosynthesis dropped to zero immediately after immersion into the oil. There were indications of a slight temporary recovery of photosynthesis starting within 30 minutes after the immersion and continuing for approximately one hour. Following this temporary recovery, however, true photosynthesis completely ceased.

Respiration continued at the original rate for approximately one hour after the immersion in oil. It then gradually decreased until it reached zero some two hours after the immersion.

Definite wilting of the leaf was evident 60 minutes after the oil was applied. The time of this wilting is depicted by the dotted vertical line at the 1 hour 30 minute mark.

Slide 5 - The immediate effect of a petroleum naphtha on the transpiration of a mustard leaf.

y-axis is the percent of the maximum rate of transpiration at the beginning of the experiment.

x-axis is the time, in minutes, at which readings were taken.

"Apparatus" represents the apparatus lag determined in a similar manner to that described for photosynthesis under slide 1.

"Oil"--represents the transpiration of an attached mustard leaf treated with a petroleum naphtha while in the apparatus leaf chamber. The oil was applied as drops in sufficient quantity to cover the dorsal surface of the leaf.

"Detached"--represents the transpiration of a detached mustard leaf. This leaf was deprived of its water supply by cutting through the petiole.

The broad arrow denotes the time at which the various treatments were carried out.

Results: With mustard leaves the transpiration rate decreased approximately 35% within 10 minutes after the application of the oil. The transpiration then continued to decrease at a steady but slower rate until cuticular transpiration was reached at approximately 100 minutes after the oil was applied. The length of time required for the transpiration of an oil-treated attached mustard leaf to be reduced to the cuticular level was approximately the same as that for an untreated detached leaf.

There were no indications of recovery of transpiration for oil-treated mustard leaves.

Slide 6 - The immediate effect of a petroleum naphtha on the transpiration of a parsnip leaf.

y-axis, x-axis, apparatus lag, oil treatment and method of detaching the leaf are the same as for slide 5.

Results: With parsnip leaves the transpiration rate decreased approximately 25% within 10 minutes after the application of the oil. Transpiration then continued to decrease at a steady but slower rate until, at approximately 90 minutes after the oil was applied, it levelled off at 20% of maximum transpiration (about double the rate of cuticular transpiration for this species).

The recovery of transpiration with parsnip leaves is shown on the next slide.

Slide 7 - The effect of the application of different amounts of a petroleum naphtha on the transpiration of parsnip leaves.

y-axis is the percent of the maximum rate of transpiration as determined at the beginning of the experiment.

x-axis is the time, in hours, at which readings were taken.

"Light application"--The line labelled "light application" on the slide represents the transpiration of an attached parsnip leaf after receiving a light application of oil. The leaf was removed from the leaf chamber, plunged quickly into the oil and held there for four seconds. It was then removed from the oil, the excess oil blotted off, and the leaf was replaced in the leaf chamber.

"Heavy"--The line labelled "heavy" on the slide represents the transpiration of an attached parsnip leaf after receiving a heavy application of oil. The leaf was removed from the leaf chamber and immersed slowly into the oil. Thirty seconds elapsed from the time that the tip of the leaf entered the oil until the entire leaf was immersed. When the leaf was totally immersed it was held there for four seconds. It was then removed from the oil, the excess oil blotted off, and the leaf was replaced in the leaf chamber.

Although the amount of oil absorbed per unit area of leaf was not determined for the above two methods of application, the difference in degree of translucence following the application signified a much heavier application from the slow immersion.

Results: As a result of the heavy application of oil the transpiration of the parsnip leaf decreased to approximately 20% of the maximum rate. Transpiration then remained at the 20% level until, at approximately 3 hours after the oil was applied, it started to recover and, 5 hours after the application, it had increased to one-half the original rate. It then continued to increase but at a very slow rate. The light application of oil resulted in only a slight decrease in the transpiration, reducing it to approximately 80% of the maximum rate.

Summary and Conclusions

It is evident from the results just presented, that the application of petroleum naphthas to leaves disrupted completely and immediately the photosynthesis of all the plants tested. In fact, this disruption of photosynthesis occurred regardless of whether the plants were susceptible or not susceptible to injury from herbicidal oils. The disruption of photosynthesis, however, although permanent for mustard, a species susceptible to injury from oils, was only temporary for parsnip, a species not susceptible to injury from oils. Parsnip, therefore, was able to recover and unlike mustard was not killed by the application of oil.

It is further evident from the results presented that, when petroleum naphthas are applied to leaves, transpiration ceases permanently in mustard, but, in parsnip, it recovers after a temporary reduction. These transpiration results suggest that an interference with, or a stoppage of, the water supply

to the leaf cells may be the factor responsible for the sudden disruption of photosynthesis and for the difference between parsnip and mustard in their recovery of photosynthesis.

Before the mechanism of selective action can be fully explained, however, it will be necessary to determine what in the various plants is responsible for the difference in the interference with the supply of water to the leaf cells.

Addendum

In case questions are asked, the following may be helpful to whoever reads the paper:

1. The methods we are using have not been published but the apparatus is fairly similar to that described by Scarth et al. in Can. Jour. Res. C. 26: 94. Feb. 1948.

2. If anyone is interested, copies are available of "The herbicidal Action of oils" which was presented at Cincinnati in Sept. of this year. This paper covered the literature on the penetration, the distribution within the plant, and the effect on the physiology of the plant of petroleum oils.

3. In case there are questions regarding the mechanism of selective action it might be of interest to you to know preliminary investigations have suggested that differences in leaf anatomy may be responsible for the difference in the interference of the water supply to parsnip and mustard. The presence of parenchyma tissue surrounding the veins in the leaves of parsnip may act as a protective layer preventing the oil from entering the trachae while the absence of such tissue surrounding the veins in mustard leaves permits penetration of the trachae by the oil.

SOME FACTORS INFLUENCING THE PENETRATION AND MOBILITY OF CHEMICALS IN THE MESQUITE PLANT

C. E. Fisher and Dale W. Young (1)

Mesquite (Prosopis juliflora) is a woody sprouting shrub that occurs on approximately 75 million acres of native grassland in Texas, New Mexico and Arizona. It is generally considered undesirable because it has within recent years invaded choice grazing lands, often forming dense jungles of brush. Mesquite in moderate to heavy infestations has reduced the productivity of grasslands by competing with desirable herbaceous vegetation for moisture, plant nutrients and in some instances light. It also has greatly increased the difficulty of properly managing and caring for livestock and the use of other desirable range practices.

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Mesquite is a highly variable plant that exhibits many different growth forms ranging from a small shrub to a large tree. Climatic, edaphic and biotic factors largely account for the variation in mesquite although there is a species difference. Nevertheless, all species have a well defined dormant bud zone on the underground stem. These dormant buds, generally 3 to 8 inches below ground level, must be destroyed or the new sprout growth will be more objectionable than the original plant. True roots of mesquite are free of dormant buds and do not sprout.

Mesquite control investigations at Spur include studies of mechanical, chemical and biological control measures. This paper is a report on some of the factors involved in chemical control.

Chemical Control of Mesquite

Mesquite may be killed chemically by using toxic materials that are absorbed and translocated to the bud zone in lethal amounts when applied to (1) foliage and tender stem tissues, (2) cut surfaces of stems, (3) roots and (4) by applying contact poisons directly to the bud zone.

Foliage Treatments.

Early work consisted of treating the sprout growth at different stages of development after the original growth had been destroyed mechanically or in some cases by fire. More recently studies have been extended to include foliage treatments on original more or less shrub-like growth of mesquite.

Sodium arsenite, sodium arsenate, sodium chlorate, ammonium sulfamate, sulfamic acid, ammonium thiocyanate, 2,4-D and 2,4,5-T are the only chemicals out of several hundred tested that have been absorbed by the foliage and translocated in sufficient amounts to completely kill all dormant buds on the underground stem. The absorption and translocation of these chemicals, however, takes place under limited conditions which seldom prevail in the southwest. Comparison of results from treatments made on 80 different dates of treatment on plots at 50 to 100 trees from 1942 to 1947 show that the absorption and translocation of sodium arsenite was almost wholly determined by the length of time that the chemical was in moist contact with the leaf surface. During the months of May, June, July, August and September spray applications followed within 24 hours by heavy dews, fogs or light rains in every case resulted in excellent translocation of sodium arsenite from foliage to underground stem in sufficient amounts to give complete plant kills of 90 percent or higher. The average moist contact of chemical on the leaf surface exceeded 8 hours under these conditions. When the moist period of contact was reduced to 4 hours excellent kills were obtained of above ground growth, but movement of sodium arsenite into the underground stem was irregular and percentage kill of plants was greatly reduced. With short periods of moist contact frequently the plants were defoliated and stem tissues were injured very slightly, if at all. Other chemicals have reacted in similar manner although there are some exceptions.

Increasing the concentration of chemicals in the spray solution or increasing the rate of application beyond adequate coverage with lethal amounts of chemicals did not improve translocation although a higher percentage kill of

above-ground growth was often obtained. Ammonium sulfamate showed increased translocation under apparent conditions of moderately short periods of moist contact, when the concentration was increased to above two pounds per gallon. Examinations made at night showed that enough moisture was absorbed from the air by the rather heavy layer of ammonium sulfamate to rewet the leaves.

The use of acids, glycerine, calcium chloride, zinc chloride, sodium pentachloro-phenol and others failed to increase absorption and translocation of sodium arsenite and ammonium sulfamate sufficiently to materially increase kills of mesquite. Rewetting with water, respraying and treating foliage at all hours of the day and night also failed to increase absorption and translocation because the moist period of contact was generally much too short of the time required.

Extensive trials from 1945 to 1948 on sprout growth and trees indicate that the degree of absorption and translocation of 2,4-D and 2,4,5-T is governed largely by length of moist contact with the leaf surface. Under conditions of long periods of moist contact the sodium salt, ammonium salt, methyl, butyl, and isopropyl ester formulations of 2,4-D and 2,4-D acid in carbowax at 2000 ppm acid equivalent basis, in water all gave excellent kills of the above-ground growth of mesquite and retarded regrowth from the bud zone for a period of 2 years after treatment. The same formulations under conditions of short period of moist contact with the leaf surface gave fair to good top kills but regrowth from the bud zone was rapid 60 to 90 days after treatment. During periods that were generally unfavorable for the translocation of 2,4-D somewhat higher kills at above-ground growth were obtained with the ester formulation than with the amines, sodium or ammonium salts, however, translocation was not increased sufficiently to prevent rapid regrowth from the bud zone. Furthermore, increasing the concentration of 2,4-D and 2,4,5-T beyond lethal amounts in formulations tested tended to increase the kill of above-ground growth but failed to materially affect translocation to the bud zone or to prevent rapid regrowth.

More recent studies with butyl and isopropyl ester formulations of 2,4-D in diesel oil, naphtha, kerosene , deobase, and Shell Horticultural Base 7 oil show that excellent top kills of sprout growth and trees may be obtained under a wider range of atmospheric and plant conditions than when water is used as the diluent; however, translocation has not been increased. Specially prepared oil emulsions of the sodium salt of 2,4-D appear to be almost equally as effective as the ester formulations in water or oils for killing the above-ground growth and show a tendency to translocate more readily to the bud zone of mesquite.

Comparison of 2,4,5-T and 2,4-D in the isopropyl ester formulation in water and oil shows that 2,4,5-T is considerably more toxic and translocates more readily to the bud zone. Rather effective translocation of 2,4-D and 2,4,5-T has been obtained during months of May, June, July and August when plants were in heavy foliage actively growing and conditions favored long periods of moist contact of a chemical on its leaf surface. Rapid growing sprouts with a limited leaf surface were moderately resistant to most formulations of 2,4-D.

Techniques Used to Study Absorption and Translocation of Chemicals in Mesquite

With an ever-increasing number of new formulations of 2,4-D, 2,4,5-T and other untried chemicals there is urgent need for some simple and rapid method of evaluating these materials for weed control purposes before any extensive, time-consuming and more expensive field trials are undertaken. Using field studies alone it is seldom possible to properly evaluate a new chemical within a period of two years because of (1) wide variation in external and internal factors affecting the plant, (2) difficulty of tracing the chemicals in plant tissues, and (3) possibility of regrowth from dormant sprout buds 12 to 24 months after treatments are applied. Therefore, several injection techniques have been used to learn something of the absorption of a chemical and its mobility within a plant. Leaf and stem injections for periods of 1 minute to 196 hours clearly show that some formulations of 2,4-D act largely as contact agents. Others may translocate for distances of 20 to 30 feet from the point of injection. The distance of translocation of most chemicals in mesquite is easily observed and determined by toxic effects on foliage. By use of the tip injection technique it was found that the sodium salt of 2,4-D was absorbed rather slowly, requiring a period of 10 hours continuous wetting before any translocation of 2,4-D was evident. When the sodium salt of 2,4-D was dissolved in water and then emulsified with diesel oil translocation was evident within a 3 hour period. It was also found that amine formulations of 2,4-D were rather slowly absorbed by leaves but over long periods of injection that translocation was greater than for sodium salt and esters of 2,4-D.

Injections of root tips has also given valuable information on movement of chemicals within plant tissues as influenced by the chemical itself, plant condition, temperature and other factors. For instance, in several cases, ammonium sulfamate was rapidly taken up by the leaves and plants were completely killed with a single 6 hour injection. Root injections of ammonium sulfamate, generally showed only limited absorption over very long periods and minor effects on normal plant growth. Other chemicals showed very little difference in rates of absorption whether applied to the roots or to the foliage.

Another technique that has been used successfully to develop information on translocation consists of treating a 6-inch portion of stem and leaves of mesquite, while carefully protecting the remainder of the plant from chemical treatment. The use of a small atomizer-type of sprayer permits almost any rate of application desired. The amount of translocation can be easily determined by the amount of stem tissues affected.

Treatment of Cut Surfaces

Early work was largely concerned with chemicals that were absorbed rapidly when applied to freshly cut tissues of the stem or sapwood of decapitated plants. Sodium arsenite, one of the first chemicals tried, has been used many years for killing sprouting shrubs since it is highly toxic in low concentrations and has the ability to move freely in both living and dead tissues. Extensive studies showed that movement of sodium arsenite was primarily vertical with limited tangential movement when applied to freshly cut surfaces of decapitated plants. The distance of movement was almost directly related to concentration of sodium

arsenite solution applied to freshly prepared tissues and closely approximated diffusional movement from cell to cell as reported by Crafts. The length of moist contact with freshly prepared plant tissues also influenced movement of sodium arsenite. Long periods of absorption greatly increased both vertical and tangential movement. The differentiation and division of tissues of the plant especially the underground stem appeared to restrict movement of sodium arsenite. The time interval between preparation of sapwood and treatment was also important, but season did not influence the movement to any appreciable extent.

More recent studies indicate that the movement of ammonium sulfamate and with certain exceptions of sodium salt and amine formulations of 2,4-D in water is governed by about the same factors as was the case with sodium arsenite. The movement of water soluble formulations, however, was greatest during the spring after plants had reached the full leaf stage when results are compared with treatments made during spring dormancy, summer or fall. The ester formulations of 2,4-D appeared to be less mobile than the sodium salt or amine in water. In diesel oil, kerosene, deobase, and naphtha the ester formulations generally showed only limited movement from the point of application.

Iri-chloro-phenoxy acetic acid as an isopropyl ester formulation from studies made this year apparently is absorbed and much more mobile than some ester formulations of 2,4-D and perhaps superior to water soluble formulations of 2,4-D. Furthermore, 2,4,5-T has shown considerable movement when used in water, oily emulsions, or in oils.

Soil and Basin Treatments

Kerosene, diesel and similar oils have been used extensively for eradication of mesquite because of their toxicity, general availability and freedom from poison hazards. The toxic action of these oils is limited with few exceptions to tissues reached by physical contact and any lateral or vertical movement is due almost entirely to capillary or gravity action. Since kerosene and diesel oils are contact agents sufficient amounts must be applied around the base of the plants to obtain complete wetting of the underground stem. The volume of oil needed varies with growth habit of plants, tree size and soil factors of texture and moisture.

Sodium arsenite solutions of 1 part stock solution and 5 to 10 parts water have been absorbed by the mesquite plant both by roots and by penetration through the bark of young plants. The poison hazard of sodium arsenite generally overshadows any value it may have over kerosene or diesel oils.

Ammonium sulfamate, sodium chlorate, boric acid, and common salt when applied in water solutions have shown no tendency to be absorbed either by the roots or by penetration through the bark of the underground stem. The sodium salt, amine, and ester formulations of 2,4-D in water are absorbed by roots, and to some extent through the bark. In general at least 1 quart of 5 percent 2,4-D acid equivalent basis, was required for effective kills of medium-sized mesquite plants. The use of isopropyl ester and butyl ester formulations in diesel oil did not appear to increase movement or percentage of kills over oils alone, however, quicker effects were noticed when 2,4-D was added to oils.

In water 2,4,5-T as an isopropyl ester did not appear superior to similar formulations of 2,4-D when applied in 2.50 and 5.00 percent amounts at rate of 1 quart per tree. On the other hand, in diesel oil 2,4,5-T at 1.25 percent amounts increased percentage kills from 10 to 85 percent over diesel oil alone when as little as 9 ounces of solution were used per tree. The addition of 25 percent diethylene bromide (Dowfome 40) also increased percentage kill of mesquite from 10 to 85 percent when an average of 4 ounces of the solution was used per tree. Tetrachloroethane showed very low toxicity to mesquite.

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Friday, December 10

Abraham Lincoln Hotel Ballroom

SECTION II - EDUCATIONAL PROBLEMS IN WEED CONTROL

E. P. Sylwester, Chairman

INTRODUCTORY REMARKS BY CHAIRMAN

When, for the betterment of agriculture, any new agricultural practice is to be promoted or an existing, deep-rooted agricultural practice is to be changed, education must spearhead the change. Before we, as Extension workers, can conscientiously and honestly recommend new methods in weed control we must have scientific information based on facts. In the last few years such momentous strides have been made in all phases of weed control that advances made in many other agricultural developments in recent years pale into insignificance by comparison. Whereas, twelve short years ago, we encountered the attitude that "Weeds are the primary responsibility of the individual farmer" and where we had three full time Extension specialists in weed control we now have many Extension specialists who devote their entire time to weed control, plus a fully alert weed control minded chemical and equipment industry ready to furnish supplies and equipment for the battle against weeds. We have constantly talked about good seed, good rotations, the prevention of weed seed production, clean cultivation, the use of smother crops, and their extensive uses for weed control. These are familiar subjects to anyone who has been in Extension weed control work. We have also talked about chemical control such as the chlorates, Atlacide, Ammate, borax, iron sulphate, etc., for a long time. Consequently, neither cultural nor chemical control of weeds is completely foreign to anyone. It remained for 2,4-D , however, in the three short years that have just come to a close, to create an interest in weed control, the like of which has not been equalled in very many lines of work for some time. It remained for the chemical and equipment industry to literally pick itself up by the boot straps, as it were, and from a standing start accomplish one of agriculture's most momentous requirements, namely, to furnish at least nominally sufficient chemicals and machinery for weed control application.

Admittedly, when any industry or educational or research program moves that fast, some mistakes are likely to occur. I believe, however, when you consider the immensity of the whole chemical weed killing field, relatively few disastrous mistakes were made. This is a credit to the entire undertaking. As an example, I might mention spray drift. Everyone has known about that for some time, yet cases of injury in Iowa continue to occur. Maybe not enough publicity has been given to it, although in Iowa we have so consistently emphasized danger from fumes, spray drift and contaminated sprayers that I was certain people were sick and tired of hearing about them. Yet minor cases of injury continue to appear. It appears that the job of education is never done.

Research work that was done this year in weed control has, in the main, borne out the recommendations of the previous years. Research workers are to be congratulated on the momentous job which they have done in a comparatively few years. Where growers have followed chemical weed control recommendations to the letter, consistently good, even spectacular, results were obtained.

Educationally today we, as Extension workers, are in the strongest position we have ever been in. Never in my experience have people been more eager or more receptive to authentic weed control information than they are at the present time. They are looking to us to bring them authentic weed control information based on thorough research which will make weed control an easier, more universal practice in this coming age of technical farming than ever before.

However, finding the correct answers in the laboratory and in the field through research is only a portion of the job that needs to be accomplished in weed control. Weed control research is the fundamental practice which must precede all Extension work. But weed research work in itself is not ultimately valuable until its values are put into practice on the back 40's and back 80's of the nation. Only then is its worth to agriculture established. There are instances where valuable discoveries were put back on the shelf and were unused for years, during which they could have been used for the betterment of agriculture and humanity in general. Obviously, this will not happen with 2,4-D or any other of the weed control chemicals as evidenced by the interest of this group, or of growers in general.

In Iowa we have enjoyed our most profitable year so far as weed control Extension is concerned. We conducted one state wide weed control meeting in conjunction with the State Department of Agriculture which attracted over 2000 officials, custom sprayer operators, etc. We cooperated in conducting 22 district meetings which attracted from 200-1500 people per meeting. There were 60 county meetings which averaged over 100 people per meeting. The Des Moines Register and Tribune cooperated in sponsoring 6 field days on pest control and the average attendance was about 1600. In all there were 2753 first class letters written in furtherance of weed control and a total of 193 meetings on weed control attracted 133,019 people.

But the way of Extension teaching is not always rosy. There are many obstacles to be overcome. The way of Extension teaching, like that of the proverbial transgressor, is often hard. In order to appreciate extension problems of each other, in order to give each other the benefit of our thinking, our methods of approach, our visual aids, etc. as used in the various states, as well as the difficulties which we have encountered and now overcome, are the reasons why we have called this meeting. We have tried in the program presented yesterday and the one to be presented this morning to give every state an opportunity to give us the benefit of their experiences in Extension weed control work. We are going to call on several gentlemen in this group who will tell us about Extension weed control work in their individual states. We also have reserved the right to call upon additional people represented here for additional remarks. With this as an introduction, then, let's get to the presentation and discussion by these men. We are going to have a few minutes for general discussion either after each speaker or at the end of the program.

EDUCATIONAL PROBLEMS OF WEED CONTROL IN MISSOURI

Ross Fleetwood, University of Missouri

I assume that there are many educational problems in weed control that are common to all the states. Since I am first on the program I have the advantage of being able to list all these thus beating the rest of you to the draw, but I

believe I'd prefer to come on a little later and see how some of you are going to attack this subject.

First let me outline our situation as it bears on our problems and their solution.

1. Missouri varies from a corn, hog, bindweed, Canada thistle, quackgrass set-up in North Missouri to a cotton, Johnson grass, Bermuda grass system in Southeast Missouri. On the west we are "bothered" with the weeds and climate of Eastern Kansas and Nebraska, while on the east we have all the weeds, vines, and shrubs which can so tenaciously bedevil a farmer in the Mississippi River bottoms. In between we have thousands of acres covered with undesirable shrubs, briars and sprouts. Within these extremes of climate and soil we find practically all the common annual, biennial and perennial weeds and grasses found in the states represented here.

2. We have a quite good seed law but it still needs some improvement and refinement in its make-up, its interpretation, and its enforcement. As yet we do not have a weed control law, nor do we have any individuals in either the State Department, the Experiment Station, or the Extension Service who devote all their time to weed control work. Whatever is done must be in addition to a full time job in some other project.

3. Fortunately no threatening infestation of any particular noxious weed is present in the state. We have areas of Canada thistle, field bindweed, quackgrass, Johnson grass, Bermuda grass, but in no case are these a menacing threat to agriculture. Our annual loss from weeds is staggering but it is a loss so equally shared and habitually borne by all that it is difficult to arouse the enthusiasm which the real seriousness of the problem merits.

I presume that in the final analysis our situation is not too different than it is in many other states, but I'm sure we must use a different approach than is used in Iowa, Kansas and Nebraska, for instance, where rather comprehensive weed laws are carried out with a fairly large personnel. However, our farmers demonstrated this last year that if we have something which works they will readily take hold of it. Therefore, I believe in all seriousness that our major problem in educational work on weed control in Missouri right now is further research information.

I would like to list some needs for information on the basis of crops or land use:

1. Cultivated crops.

Our row crops in Missouri are corn, soybeans, cotton and tobacco. At the present time we know pretty well how to control broad-leaf weeds in corn but our pre-emergence spraying designed to control grasses failed to function in our season this year.

Soybeans are very difficult to safely spray with present chemicals and there is no practical chemical control for weeds in either cotton or tobacco. We need chemicals which will control grasses in corn and control both weeds and grasses in cotton and tobacco and probably soybeans.

2. Small grains.

a. Since grasses and legumes are included on most of our small grains we have the problem of controling the weeds without serious injury to either the weeds or the small grain.

b. Our small grain acreages are usually small and do not lend themselves to airplane spraying as is the case in some areas.

3. Pastures.

We need to know how to kill the various weeds, shrubs and sprouts and still maintain good legume stands in our pastures. We haven't made too much progress with mowing because this hasn't proven too effective.

4. Brush land.

Since most of this area is in our low fertility, quite stony, Ozark region we are dealing with cheap land. Therefore, we need a cheap effective method of killing sprouts and maintaining at the same time a cover which will control erosion. Our farmers are keenly interested in this problem and are anxious to proceed as soon as practical means are at hand.

5. I would also like to say a word about equipment. Progress is being made and doubtless much improvement will be evident in 1949. However, many of our farmers bought, at a high price, equipment which was inadequate for the job at hand and as a result some of them will delay utilization of chemicals. I feel that our engineers need to vigorously attack this problem and develop equipment suited to the various spray jobs which arise.

In order to give as much leadership as possible in the use of chemicals in 1948, a simple program was developed.

1. All the available information and data was carefully studied and recommendations and suggestions on chemical use were prepared. These were made available to all county agents, vocational and G. I. teachers, and other educational leaders. They in turn made them available to farmers interested.

2. Meetings were held in interested counties early in the season. At these meetings, recommendations, crop reactions, chemicals and equipment were discussed.

3. Meetings were held in some counties with equipment and chemical dealers to "get together" insofar as possible on the story told to farmers on chemicals and equipment.

4. In an endeavor to get at the problems of calibration of sprayers, mixing sprays and methods of application, demonstrations were held where the interest and need seemed to justify. In addition to the objectives of the demonstrations these meetings served as another opportunity to discuss recommendations using chemicals.

5. Result demonstration meetings and tours were held where practical. These meetings showed the result possibilities as well as the failures and injurious results sometimes secured.

6. Finally a series of brush control demonstrations were carefully set up in nine counties to serve as a nucleus for arousing interest in this problem.

In conclusion it might be well to say that in spite of the problems encountered thousands of farmers did successfully use 2,4-D, sodium chlorate and Ammate last year. There is every reason to believe that many more thousands will use chemicals in 1949. Our real educational problem seems to be one of maintaining a conservative understanding use of new weed control methods. This is quite a contrast to the usual situation where the big problem is to arouse interest, sell the idea and secure successful adoption of the practice.

EDUCATIONAL PROBLEMS IN WEED CONTROL

Geo. M. Briggs - Extension Agronomist, Wisconsin

Being given the broad assignment of "Educational Problems in Wisconsin on Weed Control" I hedged a bit and instead have given a brief on a few of the problems that I have, which after all I presume are common problems in most any state and have taken up a few phases of the educational program that I feel I need help with. As the only weed specialist - and this along with other agronomy projects - the project perhaps gets slighted in many places. To the State Agricultural Dept. Seed and Weed Division, to many commercial concerns who help with research funds and with materials and aid at demonstrations throughout the state, goes a lot of credit in helping in the educational programs, along of course with a group of county agents, custom and private operators, town and county officials. The problems of service in materials, simplifying spray material information, problem of equipment and materials, problem of keeping farmers properly informed, and dealers and salesmen up-to-date on our recommendations is about the same problem I presume in Wisconsin as any other state.

The few problems on weed programs I need help to clarify are the following:

1. Where does extension end and action programs begin?

Attention - interest and action - the three steps in all programs - whether we know it or not - surely applies in weed control. In that we do have now such excellent weed control practices, I believe we can look to action agencies stepping in our weed control program - sooner than heretofore, or closer to the educational phases. After most of the people in any local community have been given opportunity to be exposed, and with a majority that have been at meetings, and demonstrations and seen for themselves how effective new control methods can be - and have perhaps taken part in discussions, how essential in a weed program for all adjoining property owners to play ball with the team - now with all of this over the dam - yet there isn't complete compliance. It's here I wonder if it isn't time to let loose and have action, or better call it legal programs, take over. We have for years tried to arouse enough interest so as to bring about acceptance and complete compliance, but often it seems we have come just to the top of the hill but didn't have enough of this "gumption" within to make the grade and no one gave a push. So it's been for many years that through education alone, with no one to step in and care for the few delinquent and non-co-operating farms, that reinfestation was permitted, communities get discouraged, and whole problem of gaining confidence and bringing about community action is again necessary. As I come to the end of 32 years' extension work -

many of them in weed control - I ask myself "Is it possible that losses from weeds are not as great as we estimate and really know?" The laws surely recognize that weed control is of consequence and is of community interest - and to this end those provisions that have to do with county and township weed prevention and enforcement are all outlined - provisions are outlined for taking care of menaces - yet when we see weeds getting worse in some communities it indicates something lacking in the hookup of education and legal action, or is the whole program wrong, or have we who have been developing the program lacked in co-operative understanding with legal action programs for following through?

I think those of us in educational work should not criticise people who lack interest in programs where we have not given them opportunity to be exposed to information and weed seed prevention and weed control measures - but when people, have been exposed - then to find that reinfestation is evident only because legal agencies have not followed through - then isn't it time we educational agencies examine our own programs to see if we have gone all the way out to use every human appeal - and if we have done so - I believe we should expect and would get the co-operation from action agencies to bring about complete compliance and continued co-operation.

I know that compliance can, and is being brought about in many places - but in too many it is not. People have become calloused - almost immunized to law enforcement as far as weed control is concerned. I would like to cite as examples of what is really being done under existing regulations in cleaning up and bringing about community approval and cleanup. The example set by John Hefty, in Dane Co., Wisconsin, with his town board backing, indicates to me that it isn't new laws - it's the desire on part of local people to do something about weed control that starts the ball a rolling, and hook this up with local enforcement officer, backed up by the state action agency, and mountains can be moved.

Can we exempt our obligation and blame farm operators for getting calloused when laws are constantly being violated and not much done about it. John Hefty is a law to himself - he is a grand educator and enforcement officer - brings about accomplishments because he has the backing of the majority of the town board and knows how to make approaches, brings about action and still be friends. In this township where I mention John Hefty - this exhibit shows where John Hefty visited 140 farms last year. It indicates where he influenced 70 of them to handle their Canada thistles so that they wouldn't spread. It shows those 31 farms where he used the township spraying outfit for caring for patches of thistles. The only one area left was center of a renter's farm where labor didn't hold out. Fine thing about it - John destroyed many thistles with spray outfits on many farms - charged it up to the operator and still is their friend.

2. <u>In getting complete preventive measures practiced, and having better understanding with college departments and other agencies</u>

Farmers remind me every so often when weed seed problems arise that "they have never used anything except the best of inspected seed and yet weeds are spreading - new ones coming - old weeds becoming spread more." Despite the many laws trying to protect farmers from getting weed seeds - more and more spread of weeds because of loop holes outside the laws. Despite the fine legal checkup, weeds are spreading - which means that there are still too many sources for weed seeds to come from.

I knew of a farmer who sold off his livestock so that he could get his farm freed from weeds. No more bringing in weedy mill feeds, hays or grains. The infestations on many farms because of feeding weedy grain or forages and direct application of the manure is one of the problems we have - because composting manure is wasteful of time and fertility. Drilling corn as a practice may be more economical of time, in many places necessary, but no better weed-growing program could be figured out than hauling weed infested manure direct to the field, or permitting weeds to mature in corn fields, be it drilled or checked.

Thin seedings of grain may be better for new seedings - and practical means of preventing lodging - but it is in such places that weeds thrive. Our advocates of "America the Beautiful" think we are too aggressive to advocate weed spraying along highways because of destroying weeds and brush that add to the beauty and provide nesting places for birds and so - these problems which are outside the law, strictly educational - may be the means of continuing weed problems and add confusion, lack clarification and misunderstanding, and such, indicate that strictly educational agencies must agree - are we to expect farmers to carry out the best prevention and control programs?

3. Problem of breaking down people's resistance to community weed control

I believe this a leading problem. I'm not sure but what the Minn. "Bovee Red Wood" Co. section man plan, of years ago had much more in it than was given credit - because it had the community broken down into small units and local people volunteer as section leaders to work with only the farmers of that section. From the experience of ours this summer with County Agent Riedy of Vernon County in western Wisconsin, where the size of unit was changed from the regular township to a school district unit small enough so that people knew one another, and were 139 school districts out of 155 joined in the program, I would conclude that it's the size of unit that would have something to do with giving impetus to it. On the other hand - maybe it was the encouragement that the county gave the school district in hard cash for purchasing equipment or materials. Again I believe that phase of the program that won it over to the local people was the part where the township and county authorities agreed to control the weeds on highways and on any farm where the operator is not doing so. Another phase of the agreement that may have been partially responsible for the interest in this was the fact that 75% of the farm operators had to sign the agreement before any financial help was given, and before the township would feel duty bound to the agreement.

Maybe breaking down resistance is partially accomplished as a result of the use of plain educational devices like meetings, method and result demonstrations, testimonials playing up weed losses through lower yields and lowered quality, and increasing costs of production, use of radio, debates and posters. I also have an outline of weed commissioners' activities for 1947 - which looks so complete - that I'd say these latter educational devices are important - but didn't quite do the job until the legal aspect agreed upon, along with other devices. And when once local people - together with a town chairman and good weed commissioner decided they would do something about it - sure enough they did.

4. Training of leaders - so that identification of weeds may be known, and that complete coverage of a community is made - once a program is launched - maybe should be considered more serious than we have taken it. Too often along highways, even on farms, really serious weeds will become established before anyone becomes

alarmed, or even curious. Would it be possible to train local leaders, as town chairmen or weed commissioners to recognize weeds? How would it be if agricultural teachers, or extension agronomists, or members of the State Seed and Weed Division could ride over a few townships in each of many counties - where reports from local officers and farmers indicated some weed unknowns? I have even suggested placing redheaded stakes to be set where these patches of special bad weeds were - so that local people could profit by observing and where follow up crews could give the final dose and repeats if necessary.

Perhaps we have missed the boat in our educational opportunities in not developing leaders. In the case of John Hefty, he didn't get complete coverage of his township by threatening people if they let noxious weeds go wild. He won them over because he had the backing of the town board in getting every farmer to do something about weed control. Secondly, John got his people interested because he assured them that they could even prevent weeds from being a menace, without even destroying the crop - then he assured them that weed seeds from highways and from neighbors was ever going to be controlled, and then he told them how if they couldn't find any way to care for them he would do it at the regular rate. In all the cases there were no arrests. After the first year John was a friend to everyone - he bragged about being too old to run - too fat to fight - couldn't be budged by their threats - but after giving a good educational discussion - then followed up with as much of his legal rights as necessary - as the map will indicate - John got cooperation - complete coverage - and confidence in people that everyone was to be dealt the same way, menaces removed - and still all friends. We need more Johns - can we develop them is what I'd like to ask.

5. Problem with county and town officers of developing interest in destroying areas of very serious weeds at town or county expense rather than to leave them develop larger and larger and be a menace to whole communities

Perhaps this type of problem could be controlled by a quarantine provision - but just common sense attitude has been used I know in two instances in our state - one where field bindweed was established on 13 farms, and other where leafy spurge was found on a highway and in adjoining farmer's field, and in both cases sufficient funds were set aside to treat the areas - spread was prevented and no complaints were registered because of handling it this way.

These problems I am sure are not in Wisconsin alone, and I will welcome suggestions for correcting some of these problems - which perhaps for most part is a problem of human relations.

REPORT OF CHEMICAL WEED CONTROL IN NORTH DAKOTA IN 1948

R. B. Widdifield, Extension Agronomist, NDAC

The increased interest and use of chemicals in weed control in North Dakota in 1948 as compared to that in the preceding year, well over a 1,000% increase, represents a remarkable change in a crop production practice in such a short period of time. A similar development occured in other states as well which indicates the general alertness of farmers and their confidence in quickly adopting improved crop production practices recommended by the Extension Service and Experiment Stations.

In North Dakota this season over 1½ million acres of cropland and non-cropland were treated with 2,4-D as compared to 117,000 acres in 1947. The use of sodium chlorate, Atlacide, and borax in spot treatment of perennial noxious weed patches also increased, with 688,000 pounds being applied in 1948 as compared to 488,000 pounds in 1947. The use of dinitros in selective weed control was reduced considerably, however, with 16,000 acres being treated in 1948 as compared to 58,000 acres in 1947.

About 93% of the acres treated with 2,4-D was applied to growing grain crops of which spring wheat, our leading cash crop, represented about 63%, barley 14%, flax 10%, oats 9%, with the remaining acreage consisting of rye, corn, other crops, and on summer-fallow. While the 932,000 acres of wheat treated with 2,4-D this season represents only about 10% of the 1948 wheat acreage and the flax treated on 141,000 acres also represents only about 1/10 of the flax acreage, the increased use of this weed control practice is a startling development for one years time.

About 110,000 acres of non-cropland treated this season with 2,4-D was applied mainly to solid areas or patches of field bindweed, sow thistle, and Canada thistle with the remainder being applied on Russian knapweed, leafy spurge and a number of other annual and perennial weeds.

A state wide survey of County Extension Agents made in North Dakota this fall based on their observations, experiences and estimates indicates some interesting figures in regard to methods of application of 2,4-D. Of the 1½ million acres treated with 2,4-D in 1948, ground spray accounted for 66%, ground dusting 7%, airplane spray 21%, and airplane dusting 5%. In equipment for applying 2,4-D the big increase this season was privately owned ground spray rigs with over 8,000 privately owned ground sprayers in operation in 1948 as compared to 240 in 1947. Other equipment used this season privately owned included 69 ground dusters, 45 airplane sprayers and 4 airplane dusters. Custom rigs in operation in the State this year included 168 ground sprayers, 21 ground dusters, 86 airplane sprayers and 17 airplane dusters.

Pre-emergence treatment with 2,4-D was not recommended for general farm use in the State this year. However, seventeen counties reported that it had been tried out by farmers on a small scale this season with results varying greatly and being generally unsatisfactory. At the present time it would appear that pre-emergence treatment with 2,4-D would not have any practical farm use in North Dakota.

With such a wide adoption of chemical weed control in the State this season it could be expected that considerable injury would have occurred with thousands of farmers using 2,4-D as a selective weed control measure for the first time. Results generally, however, were very good. Some injury occurred, however, although it represented less than ½ of 1% of the acres treated and a large part of the injury reported was in a relatively light degree. 27 counties reported some damage resulting from 2,4-D treatment of growing grain crops. In most cases such damage was on a relatively small acreage or to a slight degree reducing yields up to 20 or 25% and some reports of delayed maturity were received. Some of the injury was as a result of burning at the time of application with some later plant abnormalities occuring. A few scattered reports were sent in of small acreages where serious damage occurred with an occasional complete

loss of the crop but comments usually accompanied such reports to the effect that too heavy a rate of application was used, that 2,4-D was applied in the boot stage, pre-blossom stage, etc.

About harvest time reports indicated a few scattered fields of wheat showing serious injury. Symptoms included partially filled to sterile heads resulting in serious yield reduction and often included a distinct browning of the upper stem. Most of such fields reported had been treated with 2,4-D although the same conditions were found in some untreated fields. Some cases of rather severe burning at time of application were reported from airplane application of esters in oil and in certain localities grain fields showed strips of injury down through the field apparently as a result of faulty distribution of the 2,4-D material applied by airplane with too heavy an accumulation in the center of the swath.

In several areas of the State rather serious reduction of yield in wheat fields occurred where a combination of circumstances made it very difficult to lay the blame entirely to the use of 2,4-D. In such areas rather serious conditions of root rot were prevalent in the spring and high temperatures and drought conditions occurred at blossoming time. While most of these fields reported had been sprayed with 2,4-D not all of the blame could be laid to its effect and occasionally the same type of injury could be found in wheat fields not treated with 2,4-D. Farmers generally were well satisfied with the results of 2,4-D weed control in 1948 and every County Agent in the State reported without exception that they expect from a slight to a big increase in the use of 2,4-D in 1949.

Four counties in North Dakota reported that they had tried out small demonstrations with some of the other chemicals for weed control including TCA, Ammate, and 2,4,5-T. Farmers in the State generally are looking forward to a weed control chemical that will be effective and economical in the control of grassy weeds and particularly for patch control of quackgrass. Leafy spurge is a serious weed pest in North Dakota and a chemical that would be effective in its control would be a great advancement in the weed control program of North Dakota. While it is believed that chemical weed control is not the entire answer to the weed problems in North Dakota and that a long-time effective weed control program must also include such practices as use of clean seed, cultivation and seedbed preparation, use of grass and legumes in a long time rotation, pasturing with livestock, etc., there is no doubt but that the recent advance of chemical weed control has been a great step forward in effective weed control programs.

EDUCATIONAL PROBLEMS IN WEED CONTROL IN NORTH DAKOTA

R. B. Widdifield, Extension Agronomist

Educational problems in weed control in North Dakota for the coming crop season have been created by the tremendous increase in interest for chemical weed control occurring during the past year. This is a relatively new practice with which farmers are not generally familiar either with the use of selective chemicals or in the use of field equipment for the application. This increased interest is illustrated by the fact that 2,4-D was applied to well over 1½ million acres in North Dakota in 1948 compared to 117,000 acres applied in 1947.

Also, the use of sodium chlorate, Atlacide, and borax increased this past season by over 30%.

Educational work in weed control was carried out in North Dakota this year including mainly: (1) 50,000 circulars distributed on recommendations for using 2,4-D. (2) Three other leaflets on weed control published. (3) Training meetings and demonstrations held for County Agents. (4) A state-wide weed meeting held. (5) County meetings and demonstrations in all counties by agents. (6) 15 demonstrations on summer tours. (7) Exhibit prepared for State and County Show. (8) Commercial firms also carried out a lot of good educational work which was quite largely correlated to our recommendations.

For such a big development in one season and for a new practice, the results were exceptionally good this year. Some injury did occur to growing crops treated but reports indicated this injury to be less than 1/2 of 1% and much of this injury was very slight. Most injury could be traced to improper application as to amount of 2,4-D applied or to the stage of growth. Some cases of injury were the result of faulty application where parts of the swath received a heavy concentration and other parts too little. We have a combination of factors occuring in North Dakota this season where root rots were quite prevalent last Spring, high temperatures and drought occuring at blossoming time and the application of 2,4-D which made it difficult in some cases of reported injury to really lay all the blame to 2,4-D application alone.

Another condition that occured in the State this year which was quite general throughout the State may pose an educational problem for the coming season. An early drought occured at about the crop development stage recommended for application of 2,4-D which resulted in crops and weeds both being in somewhat of a dormant stage when in the tillared stage. As a result 2,4-D applications were not always effective in broad-leaved weed control and very little injury to crops treated at the recommended stage occured even in cases of higher than recommended application rates. As a result farmers may tend to use heavier than recommended rates in 1949 to secure better weed control with the possibility of serious injury to growing grain crops treated in some cases.

The main educational problems for 1949 as I see them on the basis of our experience during the past year in chemical weed control would be as follows:

1. To assist farmers to be better able to determine the proper stage of growth of the crop to be treated with 2,4-D for best weed control and least injury to the crop treated.

2. Proper use of equipment to secure uniform application.

3. The rate of application of 2,4-D was not generally a problem this season where farmers followed the Extension Recommendations or the directions on the label. In nearly all cases very little damage occured because of this factor. However, there may be a tendency to increase rate of application next year because of the human element - that if a little is good more would be better, and secondly because of the certain degree of dormancy at treating time last year.

4. Some difficulty occured in State last year with precipitate forming in the spraying solution and plugging up nozzles. The manufacturers have this pretty well corrected now and with some improvement in nozzles this should not be a serious problem.

I believe these educational problems can best be handled in North Dakota in 1949 by revising and publishing our Extension Bulletin to provide our recommendations for the use of 2,4-D and other chemicals on weed control, to conduct State and County educational meetings during the winter and spring, County Demonstrations and field days to be organized by County Agents throughout the State and by personal contact with farmers and custom operators all of which educational work will be based on the research work and our experience to date.

EDUCATIONAL PROGRAM IN WEED CONTROL (INDIANA)

Oliver C. Lee, Purdue University

Farmers have long waited for something new to appear that would ease the burden of weed control on the farm. The discovery of selective weed killing materials, such as 2,4-D, was so welcome that its use became popular before much needed experimental data was available. Farmers plunged into the use, so to speak, of chemicals without heeding the dangers involved when these materials were used as selective weed killers on crops. As a result, thousands of acres of corn and small grains were sprayed in the State of Indiana, prior to any actual recommendation made by the Experimental Station. Fortunately, the results were satisfactory in most cases. There were very few cases of injury by chemicals to crops.

In view of this situation, the educational program carried out during the past year in Indiana was designed primarily to guide farmers in the use of chemical weed killers and not to encourage their use. About the first of the year, the greatest demand for information was relative to: "What type of sprayer should I buy?" or, "Can I make a satisfactory piece of equipment to apply 2,4-D, mainly in corn?". Two leaflets were published, "Spraying Weeds with 2,4-D" and "Weeding Corn with 2,4-D". Some 90,000 copies of these have been published and distributed. During early spring, a series of meetings were held to familiarize leaders throughout the state with the recommendations of the University relative to the use of 2,4-D. A series of field demonstrations were scheduled in June. Nine such meetings were held in different parts of the state. Manufacturers of materials and equipment were invited to display and exhibit their wares. Prior to these meetings, applications of 2,4-D were applied to weeds in fence rows, pastures and in growing corn, so as to show results during the meetings. Equipment was demonstrated by various manufacturers. A total of 36,000 people attended these meetings. One large field day was held in cooperation with agricultural farm papers. Some 20,000 people attended this meeting, which was held in July. Equipment manufacturers displayed equipment and chemical manufacturers displayed chemicals. Plots of corn previously sprayed gave those in attendance an opportunity to see the effect of various dosages of the chemicals on corn. A tour of groups of farmers was conducted during the day. Some 30 County Agents and specialists cooperated in pointing out the results and effects of 2,4-D. Spray demonstrations

by airplane and helicopter were also conducted, in addition to ground equipment.

The results of this educational program brought about reasonably sane use of herbicides, with a few exceptions, of course. Very little damage to crops has been reported. Although the extent of spraying cannot be determined accurately, it is known that in some areas where weeds are a serious problem, approximately 95 per cent of the corn was sprayed. We have also used 2,4-D successfully for the control of weeds in small grains, the control of weeds in fence rows, in pastures and for the control of patches of Canada thistle, bindweed, morning glory and other resistant perennials.

Vegetable growers were given assistance in weed control. Many of them have adopted the use of sulphuric acid for the control of weeds in onions and the use of Stoddard solvent for the control of weeds in carrots, parsley and celery fields. These two chemicals have saved farmers thousands of dollars in reducing weed control bills.

In addition to chemical weed control, farmers have been encouraged to send in weeds for identification. Fanweed or Frenchweed, introduced into the state recently, has spread rather rapidly and has been declared a noxious weed in Indiana. Likewise, hoarycress, a western weed, has spread in the state. Plans have been made to acquaint farmers with this plant in the hope that it might be eradicated before it becomes widespread.

The use of clean seed is essential to weed control. Assistance has been given seed producers, as well as distributors, in encouraging the use of clean seed in preventing the introduction of weeds.

WEED CONTROL ACTIVITIES IN IOWA IN 1948

E. P. Sylwester, Extension Botanist

EXPERIMENTAL AND DEMONSTRATIONAL

Experimental and demonstrational work in weed control has involved a study of the tolerance of various crops to 2,4-D. Both pre-emergence and post-emergence treatments were designed to determine correct spray dosages. In oats, pre-emergence and post-emergence spraying with 2,4-D emphasizes the severe effect of 2,4-D on legume seedings. This intolerance of the legume seedlings to 2,4-D is a definite limitation of 2,4-D in weed control program involving small grain. In flax, we definitely know that this crop can be safely sprayed using the ester form at the rate of one-eighth pound per acre before the flax is 12 inches tall. This results in fairly good control of susceptible weeds. In soybeans, two preliminary tests with 2,4-D pre-emergence spraying gave conflicting results. A third test yielded some promising results which need further checking. In corn, the major emphasis has been on the tolerance of corn to the various dosages of 2,4-D. Pre-emergence sprays gave good enough weed control to save at least two cultivations and no injury to the corn was noted at the rates used. Post-emergence spraying tests, designed to test various dosages and formulations of 2,4-D, indicate strongly that tolerance of corn to 2,4-D depends not only upon the dosage applied but also on the stage of development and rate of growth of

corn at the time the spraying and growth conditions, both before and after spraying. Results obtained this year substantiated, for the most part at least, our dosage recommendations of previous years. Experimental work done was under the direction of Dr. A. L. Bakke and D. L. Staniforth.

EDUCATIONAL PHASES OF WEED CONTROL

During the period, 74 counties were actually contacted by individual county meetings of one kind or another. In addition, district meetings on weed control, regional field days, district extension training schools, and regional pest control conferences gave every county an opportunity to be contacted by some type of weed control meeting. In all, the specialist conducted 193 meetings which attracted a total of 133,019 people and embraces weed committee meetings, county project meetings, institutes, tours, field days, exhibits, pest control conferences, demonstrations, night schools, and 4-H groups. This group of people was by far the largest ever contacted in an organized way on weed meetings during any one previous year and reflects the tremendous current interest in weed control work. Much of it is due to the advent of new weed killing chemicals. All of the counties which requested meetings were helped, plus some others. During the course of the year, the specialist made 32 farm visits to problem weed areas, visited 19 result demonstrations, made 30 radio talks, prepared 21 press articles, and wrote 2753 first class letters. One bulletin was published in conjunction with the State Department of Agriculture and 30,000 copies of this major bulletin was distributed. Two major articles were published in Iowa Farm Science and 30,000 copies of each article were distributed. Three major articles also appeared in Hoard's Dairyman and at least 10 mimeographed leaflets were prepared on some phase of weed control.

In response to a thorough educational program in weed control, five of the major chemical companies sold over 100,000 gallons of the 2,4-D concentrates in Iowa this year for weed control purposes. This, at the rate of approximately one-fourth pound per acre, was enough to treat 1,600,000 acres of land for weed control. This land would include crop land, such as corn, small grains, flax, meadows, and pastures, as well as roadsides, railroad enbankments, ditch banks, fence rows, etc. Bumper yields of small grain, flax, and corn reflect in part at least, returns from a better program of weed control, in addition to commercial fertilizers, insect control, and good climatic conditions. National figures show definitely that with the increased use of 2,4-D compounds, the dockage due to weed seeds in small grain and flax is decreasing, the 1947 and 1948 crops being the cleanest in the history of the small grain and flax industry. Monetary value of crops due to cleanliness has increased accordingly. We have, in the 2,4-D compounds and in other weed killing chemicals, the means whereby we can cut the depredations of weeds in Iowa, to a minimum. Never has our weed control program been better or more enthusiastically or more gladly received than this past year. Weed control by means of chemicals is only in the embryonic stage and is only the beginning of an era in which, if we want to and set our minds to it, we can cut the depredations caused by weeds to a negligable figure. Much remains to be done in an educational way to accomplish this purpose.

Friday morning, December 10

Leland Hotel Ballroom

SECTION III - REGULATORY PROBLEMS IN WEED CONTROL

Chairman, W. L. Klatt

The meeting was called to order by W. L. Klatt. Mr. E. H. Aicher was requested to act as secretary. Reports of the Committees on Regulatory Activities were presented.

Report of the Committee on Uniform Weed and Seed Laws, Charles J. Gilbert, Chairman, presented by R. C. Colborn:

The committee on Uniform Weed and Seed Laws recommends that:

1. States not having weed regulatory agencies shall establish such agencies with adequate legal powers and appropriations for carrying out such laws to the fullest extent.

2. In order to carry out efficiently the enforcement of a noxious weed law, the list of noxious weeds be held to a minimum number. It is further recommended that the following be generally considered and included as noxious weeds for the area.

a. Canada Thistle, Cirsium arvense

b. Field Bindweed, Convolvulus arvense

c. Horse nettle, Solanum elaeagnifolium

d. Leafy Spurge, Euphorbia esula

e. Perennial Peppergrass, Lepidium draba

f. Perennial Sow Thistle, Sonchus arvensis

g. Russian Knapweed, Centaurea picris

3. There be included in the several state weed laws authorization for a compulsory program of control or eradication of noxious weeds which will include the elements of a quarantine as it would apply to areas of small or reasonable size located in otherwise relatively free areas.

4. Uniformity in state weed laws will be well served by including the provision that the seller of any grain or other materials containing noxious weed seed must so declare and designate the presence of those weed seeds to the purchaser of such grain or other materials. This law should contain sufficient provisions so as to protect successive purchasers as well as the ultimate consumer.

5. Uniformity of weed laws will be greatly benefited by having the weed laws of the several states contain adequate provisions for the financing, control, and eradication of noxious weeds found on any public lands under the jurisdiction of city, county, and stage agencies. Also there should be provisions for cooperative agreements between state and federal agencies for the control and eradication on federal lands.

6. Closer contacts and cooperation between committees of this organization and other organizations such as the North Central States Seed Control Officials, Association of Official Seed Analysts, and other similar groups.

7. Since the movement and sale of agricultural seed intended for seeding purposes are effectively regulated by the Federal Seed Act and State Seed Laws, weed laws regulating the movement and sale of grains for feeding purposes and other material should not include agricultural seed intended for seeding purposes.

8. The Conference appoint a permanent committee for the study and promotion of a Federal Weed Law which will cover the sale, transportation, and utilization of noxious weed infested grain and materials.

The adoption of the report was moved by Mr. Gilbert. The motion was seconded and adopted.

Report of the Committee on Movement of Noxious Weed Seed Infested Materials, Both Interstate and Intrastate, Sig Bjerken, Chairman:

The three objectives of a weed program are - Eradication
Control
Prevention

Eradication of weeds has been brought about largely through the combined efforts of the regulatory, research and extension people of the states and definite progress has been made along these lines. It has required the enactment of legislation from time to time in order to speed up the eradication program.

Control of weeds has been carried out on largely infested areas where it is necessary to carry out a program over a period of years due to circumstances such as the owner being financially unable to carry the burden of costs, lack of equipment, weather and soil conditions, etc., until such time that eradication can be brought about.

Prevention of weeds is one of the most important phases of our weed program and it has been brought out very clearly in carrying out the weed program that there is a definite need for an improvement along this line if we are to bring the weed program to a successful conclusion. A considerable amount of weed work has been done in vain due to areas being reinfested by uncontrolled sources and methods of distribution of weed seeds through various channels such as the movement of combines and other equipment from one area to another without being cleaned, of grains, milled feeds, forage, bedding, packing materials, railroad cars, automobiles, etc., and other infested materials, both interstate and intrastate.

Great strides have been made in the past in the enactment of strict state seed laws and a Federal Seed Law to govern the sale of agricultural seeds, while on the other hand weed seeds are being spread through these other avenues with very little restriction and still it is obvious that the average farmer buys considerable more feed grain than seed.

This Committee wishes to make the following recommendations:

(1) That further study be made as to the advisability of a federal law governing interstate movement of weed infested materials.

(2) That the enforcement agencies of the states concerned cooperate to the best of their ability in bringing about supervision of the movement of weed infested materials, until such time as proper legislation is enacted for regulation.

(3) To regulate the movement in interstate and intrastate commerce of any feed, grain, seed or grain screenings, forage, bedding, packing material or other material containing live noxious weed seeds, unless stated on the label or the invoice that the shipment is intended for processing to remove or destroy the viability of the noxious weed seeds present, and that the material complies with the laws of the state into which it is to be transported.

Mr. Bjerken moved the adoption of the report. The motion was seconded and carried.

Report of the Committee on the Movement of Transient Custom Combines, Loys F. Smith, Chairman:

The operation of transient custom combines in the West Central States from Canada through the Dakotas, Nebraska, Kansas, Oklahoma, and Texas has become a large industry. The possibility of spreading noxious weed seed and starting new infested areas by this movement is great. The problem of handling the combine traffic and cleaning such equipment to conform with state weed laws is no longer a job for the individual state but rather one for all states involved to cooperate.

The Transient Custom Combine Committee offers the following recommendations:

(1) The Committee wishes to recommend that each state secure a registration list of all combine operators in the state including non-resident operators.

a. This list may be secured through the State U. S. employment agency.

b. Alphabetize master list of names.

c. Segregate names by states and mail to each state.

d. Each state supply weed control regulations to State U. S. employment agency to be included with other information they send to all combine operators.

(2) The Committee recommends that we solicit the aid and cooperation of Dr. L. W. Hurlbut, Director of the University of Nebraska Agricultural Engineering Department, in working with the Farm Equipment Institute and manufacturers with the objective of having combine harvesters and threshing machines constructed so as to make frequent cleaning easy. We further solicit the aid of Dr. Hurlbut in conducting research incidental to the realization of this objective.

(3) The Committee recommends that the North Central Weed Control Conference appropriate the sum of $300.00 as a grant in aid to the Agr. Engineering Dept. of the University of Nebraska to assist in carrying out research to improve combine and threshers to make them more easily cleaned.

(4) The Committee also recommends that the West Central States develop similar or uniform requirements in crossing state lines and operating within states.

(5) The Committee further recommends each state conduct pre-harvest educational programs to inform combine operators and growers of small grain of legal requirements.

a. By publicity, letters, and direct contact.

(6) That each state school inspectors and others having jurisdiction over combine and threshing machine operators.

Considerable discussion followed the reading of this report. Of particular interest were remarks made by Mr. Ball of California. After the adoption of the report, the group acting as a committee of the whole passed favorably on two recommendations made by the Custom Combine Committee.

The first had to do with a recommendation that the Directors of the Conference be requested to appropriate $300 for combine research to be made available to Dr. Hurlbut of the Agricultural Engineering Division of the University of Nebraska. This was embodied in a motion by Mr. Gilbert. Was seconded by Mr. Swenson and carried.

Sig Bjerken then moved that the Committee of the whole request the President of the Conference to appoint a committee of three consisting of Smith of Nebraska, Yost of Kansas and Gilbert of South Dakota to work with Dr. Hurlbut. This motion was seconded by Mr. Lunz and carried.

Mr. Klatt then called for the report of the Herbicide Laws Committee, Warden L. Noe, Chairman. Mr. Noe, knowing he would not be present, had delegated E. H. Aicher to read the committee report.

Report of Committee on Herbicide Laws, Warden L. Noe, Chairman, presented by E. H. Aicher.

Your Committee composed of L. W. Kephart, E. H. Aicher, Arne Carlson, Leonard Schrader, (Clayton B. Kelsey), N. F. Hall and Warden L. Noe, as Chairman, have collaborated on the assignment given to this committee and have conferred with interested parties and are pleased to report to the conference as follows:

1. We believe that the agricultural chemical law should be amended to require the labeling of herbicides to show:

   a. The net weight of products sold in powder or solid form;

   b. The content of packages or products sold in powder or solid form;

   c. The name and percentage by weight of the active ingredient such as sodium chlorate, borax, sodium arsenite, ammonium dinitro-sec-butyphenate, sodium 2,4-dichlorophenoxy acetate and methyl 2,4-dichlorophenoxy acetate;

   d. A statement of percentage by weight of the equivalent 2,4-D acid, in solid compositions of 2,4-D type products;

   e. A statement of percentage by weight of equivalent 2,4-D acid and weight of equivalent 2,4-D acid in a unit volume, in liquid compositions of 2,4-D type products;

   f. More detailed directions for use upon the label stating the quantity of 2,4-D to be used under different environmental conditions.

2. We believe that it is desirable for the states with agricultural chemical (economic poisons) laws to supplement such laws by the enactment of further legislation: (a) requiring the control and regulation of operators of airplanes and ground equipment who disperse herbicide sprays or dusts for the purpose of eradicating noxious weeds; and (b) requiring that aircraft spraying equipment shall have a positive "shut-off".

3. We strongly urge that each legislative body give special consideration to the problem of the complexity of any agricultural chemical (economic poisons) law enactment. Such legislation must be workable from an administrative aspect, minimizing the details. Equally the law should be of such strength as to protect the public but not so prohibitive as to seriously deter the broad usage of these agricultural benefactors.

4. We are submitting herewith "Exhibit A" as a draft of a bill concerning requirements for control and regulation of operators of aircraft and ground machinery used in dispersing of herbicides, which we suggest be followed as a guide in the preparation of proposed legislation.

5. We recommend that this subject be given further study and consideration by succeeding committees.

6. Since this matter is of such vital concern to all states and provinces in the conference, we believe more states should be represented on the committee.

Dated at Springfield, Illinois, this 8 day of December, 1948.

Respectfully submitted,

Committee on Herbicide Laws

By (Signed) Warden L. Noe
Chairman

Moved by Mr. Yost and seconded by Mr. Smith that report be adopted.

At this point, Mr. Klatt was called out of the meeting and delegated Mr. Charles Gilbert, Chairman, Pro Tem.

The discussion was opened on how to improve the program for 1949.

Mr. Yost opened these discussions. Mr. Ball from California made contributions to this discussion.

Was moved by Yost and seconded by Smith that we officially extend to Walter Ball and the Western Conference an invitation to be with us in 1949. Carried unanimously.

Mr. Yost then presented need for more discussion on noxious weed control problems in the conference.

He suggested that representatives of Federal grounds and installations, and public lands be given place on the program. Mr. Swenson suggested the agronomist in charge of army installations be put on the program.

Mr. Gilbert pointed out the excellent weed control work being done on the ordnance plant at Provo, South Dakota.

Mr. Smith reported on the weed control activities under way on the Army and Navy ordnance plants in Nebraska.

The committee then proceeded with the selection of a chairman of this committee for 1949.

Mr. Bjerken nominated Charles J. Gilbert of South Dakota. Mr. Gilbert stated that due to the fact that he was general chairman of the 1949 Conference, he did not feel that he should be given this added responsibility and asked Mr. Bjerken to withdraw his nomination. This was done. Some discussion followed led by Mr. Yost, who again nominated Chas. J. Gilbert.

Was moved by Loys Smith and seconded by Swenson that nominations close and that a unanimous ballot be cast for Mr. Gilbert. Carried unanimously.

Was moved by Yost, seconded by Swenson that the committee adjourn.

Carried.

(Signed)

E. H. Aicher
Secretary

EXHIBIT A

House Bill No. _____

An Act relating to the registration of owners and operators of aircraft and ground machinery used for dispersing of herbicides; prescribing certain requirements, powers and duties; and providing penalties for violations.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF _____:

Section 1. As used in this act the following words shall be given the meaning as defined:

(a) The term "herbicide" means and includes any substance or mixture of substances, labeled, designed, or intended for use in preventing, destroying, repelling, or mitigating any weed.

(b) The term "weed" means and includes any plant which grows where not wanted.

(c) The term "person" means any individual, partnership, association, corporation, or organized group of persons whether incorporated or not.

(d) The term "secretary" (Director or Commissioner) means the secretary of the _____.

(e) The term "registrant" means any person registering aircraft and ground machinery, under this act.

(f) The term "aircraft" means and includes heavier than air, propeller driven airplanes and helicopters of any type, which have been equipped with apparatus designed for, or susceptible for, use to disperse liquid sprays, dusts, aerosols, or fogs from the air.

(g) The term "ground machinery" means machinery designed for, or susceptible for, use to disperse liquid sprays, dusts, aerosols, or fogs from machinery operated on the ground.

Section 2. It shall be unlawful for owners or operators of aircraft or ground machinery to disperse herbicides or other chemicals on agricultural or horticultural lands, on crops, forests, swamps, or on other areas, or to use such equipment and machines for any of such purposes without first having registered such aircraft and ground machinery with the secretary. The registration fee shall be _____ per registration for each owner or operator and an additional _____ for each piece of aircraft or ground machinery. Such fees shall accompany an application for registration to be submitted on a form supplied by the secretary. All registrations shall expire on December 31 of the year issued. All operators of aircraft or ground machinery shall be bonded. The applicant for registration of aircraft and ground machinery shall execute and deliver to the secretary in conjunction with his application a bond executed by the applicant, as principal, and by a solvent surety company licensed to do business in the State of _____, as surety. Said bond shall be in the

sum of $_____ and shall be for a term of not to exceed one year, but shall extend to cover the current registration period. Said bond shall be to the State of_____, and shall be conditioned upon compliance by the principal, his agents, servants, employees and licensees with the provisions of this act and for the use and benefit of such person or persons as may suffer loss or damages by breach of any of the conditions thereof.

Section 3. The secretary is authorized to inform the owner or operator of aircraft and ground machinery who applies for such registration of the dangers involved and precautions to be taken in the operation of such aircraft and ground machinery and pertinent equipment in order to prevent: (a) drifts of sprays or dusts to areas other than those areas for which it was intended; (b) overdosing and underdosing; (c) cumulative undesirable effects from repeated applications; (d) undesirable effects from applications at improper times or stages of growth.

Section 4. The secretary is authorized to require any person who applies for such registration to first take an examination as to his knowledge as to the formulation of the correct dosage of the product or products which he proposed to use; as to the general effect of the spraying on crops, beneficial insects and other forms of plant and animal life beneficial to man. The secretary may hold in abeyance the application for registration of owner or operator: (a) until such time as the applicant shall upon examination show adequate and acceptable knowledge concerning the mixture and use of herbicides, machinery for their dispersal, and other subjects required by the secretary, including acceptable standards as to solutions, rates of application, and time of application; (b) until applicant's aircraft or ground machinery has been examined and found to be equipped with the features required by the secretary.

Section 5. The applicant at the time he applies for registration, shall give his name and permanent address and the location of temporary headquarters where his aircraft or ground machinery will be normally stored between field operations; and if he be a non-resident he shall give the name of a resident agent authorized to accept service of summons; he shall also supply such other information as may be required by the secretary.

Section 6. Each registrant shall list and report to the secretary not later than seven days after the end of each calendar week, his activities during the previous week and shall note (a) the completion of each spraying or dusting job, (b) the location of the area treated, (c) the name of the landowner or employer, (d) the kind of herbicide used, and (e) the quantity of herbicide applied per acre.

Section 7. The secretary is authorized to enter into agreements with federal or state agencies, and with private concerns and individuals for cooperative control demonstrations in order to demonstrate to the public the feasibility of control methods for herbicidal spraying and dusting with aircraft and ground machinery.

Section 8. For purposes of enforcing this act, the secretary, and his authorized representatives, shall have authority: (a) to enter upon public and private premises and shall have access, ingress, and egress to and from airports, hangars, storage sheds, and to and from other property where aircraft and ground machinery are being used or stored; (b) to examine and test

herbicides, aircraft and ground machinery, equipment, containers, and other accessories.

Section 9. Registration with the secretary shall not exonerate the owners or operators of aircraft or ground machinery from responsibility for damage resulting from overdosing, underdosing, or misapplication of herbicides.

Section 10. The funds collected shall be paid into the state treasury for the use by the secretary in the enforcing of this act.

Section 11. This act shall not apply to any person owning aircraft or ground machinery when operating the same upon or over land owned by such person, his neighbor for barter or exchange, nor to Federal, State or Political Subdivisions.

Section 12. The secretary shall have authority to refuse registration and may, after hearing, revoke registration certificate for: (a) faulty or careless application of herbicides; (b) misrepresentation of the results which may normally be expected; (c) failure to comply with any provision of this act following an administrative determination of such failure; (d) failure to pay any final judgement entered against any registrant by reason of his liabilities under this act.

Section 13. Any person violating or failing to comply with provisions of this act shall be deemed guilty of misdemeanor and upon conviction shall be fined a sum not to exceed $500 or be imprisoned for a period of not to exceed one year, or of both the fine and imprisonment.

Section 14. This act shall take effect and be in force from and after April 1, 1949, and upon its publication in the statute book.

Friday afternoon, December 10

Centennial Building Auditorium

GENERAL SESSION

C. J. Willard, Chairman

In the absence of Clyde Bower, K. P. Buchholtz was appointed Chairman of the Resolutions Committee. The other members were W. C. Elder and G. C. Buskirk. K P Buchholtz presented the following report:

REPORT OF THE COMMITTEE ON RESOLUTIONS

The North Central Weed Control Conference having assembled at Springfield, Illinois, December 8, 9, 10, 1948, for the consideration of weed problems confronting agricultural and industrial workers and for a discussion of methods suggested or developed for the control of weeds, RESOLVES:

1. That a vote of thanks be extended to the host State of Illinois and the City of Springfield, to Mayor Harry A. Eielson, to the Chamber of Commerce and other city officials, to Arnold P. Benson, Director,

Illinois Department of Agriculture and especially to Charles H. Keltner of the Illinois Department of Agriculture and his workers for the many facilities made available and the courtesies extended that contributed so largely to the success of the conference.

2. That all officials and members of the conference who contributed to the program and success of the conference and President C. J. Willard and Research Committee Chairman L. M. Stahler, in particular, be commended for their devoted efforts in developing and presenting an interesting and informative program.

3. That the many commercial concerns who expressed their interest in weed control by participating in the conference be extended an expression of appreciation for the exceedingly interesting exhibit and for their great efforts in promoting the cause of weed control through the development of improved herbicides and application apparatus.

4. That the efforts of educational, regulatory, research and commercial workers be maintained at high levels so that weed control measures might become even more effective and efficient in the future.

5. That the stenographic assistance of Ann Guerrini and Jane Settles be gratefully acknowledged since they contributed generously in preparing the many reports required during the conference.

These resolutions were unanimously adopted.

L. M. Stahler, Chairman of the Research Committee, then presented the recommendations of that Committee in mimeographed form.

RECOMMENDATIONS OF THE RESEARCH COMMITTEE OF THE NORTH CENTRAL WEED CONTROL CONFERENCE

The following discussions, opinions, suggestions and recommendations are made in light of best information accumulated in 1948 by the Research Committee of the North Central Weed Control Conference. The Conference recognizes that the effectiveness of herbicides depends upon so many factors which vary so greatly from region to region that this report can in no way replace State and local recommendations. We strongly advise referring to your State agricultural experiment station for specific recommendations on the use of herbicides locally.

Recommendations suggesting rates of applications of 2,4-D are in all cases based on the acid equivalent.

A. CONTROL OF PERENNIAL WEEDS

Perennial weeds are difficult to control with 2,4-D. Best results have been obtained by treating during the active growing stage--generally near the bud stage. One application of 2,4-D seldom gives eradication. Retreatments are necessary. It is generally agreed that where eradication

is the objective, higher rates of 2,4-D have given the best results. Where long time control under cropping conditions is the objective the rate of application should be governed by the maximum amount the crop will tolerate.

1. Control of Canada Thistle.

To eliminate Canada thistle repeated applications of 2,4-D over a period of several years are generally necessary. First application should be made at the bud stage with retreatments when the surviving thistle plants are in the rosette stage. One-half to one pound of 2,4-D per acre is suggested as a range of application.

2. Perennial Sowthistle.

2,4-D has given effective control of perennial sowthistle in cereal crops when applied at approximately one-half pound acid per acre. One and one-half pounds applied at the bud-flower stage has resulted in nearly complete eradication, especially when the weed is in competition with aggressive grasses. Repeated treatments are generally necessary to eliminate surviving plants.

3. White Top or Hoary Cress.

Hoary cress may be effectively controlled by 2,4-D. Seed production is prevented, top growth stopped, and the stand reduced by one application at the bud to early bloom stage. Repeated treatments over a period of three or four years, have resulted in elimination of the weed in grass sod and on cultivated land in connection with cultivation and the growth of crops. Since hoary cress is moderately tolerant to 2,4-D the esters generally should be used. Treatments at rates of one and one-half to two and one-half pounds of acid per acre in early bloom and/or fall rosette stages are recommended. These rates will injure most crops. Plants that emerge within 3 or 4 weeks after treatment should be spot treated to assure complete coverage.

4. Field Bindweed.

Field bindweed is most susceptible to 2,4-D when just starting to bloom but may be controlled at other stages if growing vigorously. one-half to one pound of 2,4-D acid per acre is required to give practical control of this weed.

5. Leafy Spurge.

2,4-D is useful in controlling and sometimes in eradication of leafy spurge in growing crops, on summer-fallow and on non-crop land. 2,4,5-T does not offer any advantages over 2,4-D in treatments of this weed.
2,4-D at low concentrations in oil appears to be somewhat more effective than when used in water.
In a growing grain crop the weed should be treated at any time prior

to bloom stage with one-half pound of 2,4-D acid of the ester or amine salt.

For eradication purposes on summer-fallow use not less than 3/4 pound of ester or amine salt when the weed is in the bud stage and repeat this treatment throughout the growing season whenever the top shoots are three to five inches high.

In eradication work, cultivate lightly the infested area whenever possible and seed it to the grass best adapted to the climatic and soil conditions of the region. After the grass stand is established treat the weed when in the bud stage with an ester of 2,4-D at rates of one to two pounds of acid per acre.

B. CONTROL OF ANNUAL WEEDS

2,4-D can be used to control many annual weeds. However, some are resistant. Annual weeds are more susceptible in the seedling and early stages of development, and when conditions are such as to promote vigorous growth. Some weeds which are resistant at later stages of growth are readily killed when young and actively growing. In some areas the ester formulations have been much more effective in controlling annual weeds than either the amine or sodium salt. 2,4,5-T appears to be no more effective than 2,4-D. Some weeds may be controlled with dosages as low as 1/8 pound of 2,4-D per acre. State experiment stations should be consulted concerning the susceptibility of specific weeds and the dosage necessary for control.

C. USE OF 2,4-D IN GROWING CROPS

1. Use of 2,4-D to Control Weeds in Legumes Underseeded in Cereal Crops. From a rather limited amount of data it appears that recommendations concerning 2,4-D treatment of legumes seeded in other crops should include:

   a. Unless some reduction in legume stand can be tolerated, 2,4-D should not be used.
   b. If treatments are made, not more than $\frac{1}{4}$ pound of 2,4-D acid per acre in the amine and sodium salt formulation should be used. The companion crop must be approximately 20 inches tall.
   c. There appears to be differential response in different species of legumes when treated with 2,4-D. Red clover appears to be more tolerant than alfalfa.

2. Flax.

Flax should be sprayed as soon as there is enough weed growth to make it practical. Flax is susceptible to reduced yield if sprayed in the bud or bloom stage.

The ester formulation should not be used on susceptible varieties. For tolerant varieties, the rate should be approximately one-half the amount of the amine salt recommended for the area.

Varieties differ most widely in their response to 2,4-D:

a. When the ester is used.
b. When rates of amine or sodium salts are heavier than recommended.
c. When applications are made in bud and bloom stages.

3. Spring Planted Wheat, Oats and Barley.

A maximum amount of $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D acid per acre may be applied before the fully tillered stage and a maximum amount of $\frac{1}{2}$ to 3/4 pound may be applied after the fully tillered stage--except for the boot to dough stage--without appreciable reduction of yields and viability of the crop. Abnormal heads may be produced when treatments are applied at the earlier stages. The lower indicated rates should be used as the maximum amounts of the ester formulations.

4. Fall Planted Wheat, Oats and Barley.

To get the most efficient use of 2,4-D for the control of annual weeds in winter wheat, oats and barley, it should be applied in the spring while weeds are small and before the crop has reached the boot stage. At this stage $\frac{1}{4}$ to 1/3 pound of ester or $\frac{1}{2}$ to 3/4 pound of salts of 2,4-D can be used without serious injury to winter cereals. Where heavy rates are required to control perennial weeds some injury to the crop can be expected. Winter wheat is more tolerant to 2,4-D when the application is made under low moisture conditions. There is evidence that winter barley is more tolerant to injury from 2,4-D than winter wheat.

5. Growing Corn and Sorghum.

2,4-D has a place in the cornfield where susceptible weeds cannot be adequately controlled by conventional methods of cultivation. As cultivation is apparently essential on many soil types, spraying should not be considered as a substitute.

Some degree of injury to corn--including field, pop and sweet corn--from 2,4-D sprays, regardless of dosage, is to be expected, as exhibited by brittleness, lodging, stalk curvature and proliferation of brace roots. Such damage may or may not be reflected in yields. Brittle corn is subject to breakage by wind or cultivator contact.

Differences in tolerance of strains and varieties of corn to 2,4-D exist. Information concerning tolerance of different locally adapted strains should be obtained from local agricultural experiment stations.

It appears that $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D acid per acre is the logical dosage to apply. It is suggested that the dosage be held to the lower figure when the ester types of 2,4-D are used. The dosage should be determined by amounts known to be necessary to control weeds up to the limits that corn will tolerate.

Time of application should be determined by weed growth. The ideal time to apply sprays is following emergence of the majority of weeds but before weeds have damaged the corn. Growing conditions at time of spraying.

rather than size of corn determine susceptibility to injury. Greatest injury to corn results when 2,4-D is applied during periods of high temperatures and favorable moisture conditions for plant growth. When spraying small weeds in large corn (30 inches or larger) the use of nozzle extensions is suggested to assure adequate coverage of weeds that are often protected by corn leaves.

General recommendations for the use of 2,4-D in corn will apply to its use in sorghums. Only limited information relative to sorghums is available and local agricultural experiment station recommendations should be closely observed in treating this crop.

6. Perennial Grasses.

Established stands of most perennial grasses are so tolerant of 2,4-D that dosages used may be those necessary to control susceptible or semi-tolerant weeds. An exception should be made in the case of bent-grasses and buffalo grass. These grasses may be susceptible under some conditions.

Seedling grasses may be injured by 2,4-D applied at or immediately following emergence. Seedlings may be treated with $\frac{1}{4}$ or $\frac{1}{2}$ pound acid per acre after reaching the 4-6 leaf stage of growth. As the grass seedling increases in size and age, dosages may be increased. After seedlings are well tillered and have 12 or more leaves they may be treated much as established plants and expected to tolerate dosages adequate to control broad-leaved weeds.

The use of 2,4-D for control of broad-leaved weeds in grass seedlings on lands heavily infested with seeds of weedy annual grasses is inadvisable. Such treatment is often followed by increased competition by the annual grass species which cannot be controlled with 2,4-D.

D. PRE-EMERGENCE USE OF 2,4-D.

1. Corn.

Pre-emergence applications of 2,4-D are an adjunct to cultivation of corn, not a complete substitute on all soil types.

Effective pre-emergence treatment of corn with 2,4-D for weed control is dependent upon moisture, temperature, soil type, time of application and other factors. They are most effective when sufficient soil moisture is present to cause rapid weed seed germination.

a. Applications of 2,4-D are most effective for control of weed seedlings when made from three days after planting up to the time of emergence.
b. Where conditions are favorable, two pounds of 2,4-D per acre are sufficient.

Results have been variable, indicating a need for a continued and an intensified program of research.

Pre-emergence treatment of corn is recommended only when conditions are favorable, and where problems of weed control exist that cannot be solved by other means. It may have some advantages over post-emergence spraying in the control of grass weed seedlings in rainy weather which hinders cultivation.

Pre-emergence treatments of corn with 2,4-D are not recommended on sandy or light porous soils.

2. Other Field Crops.

Pre-emergence application of chemicals for weed control in grain crops, flax, sorghum and miscellaneous field crops gave erratic and generally unsatisfactory results in the North Central region in 1948. The commercial use of this technique for weed control in these crops is not recommended in the area in 1949.

E. HORTICULTURAL CROPS.

Chemical weed control measures with horticultural crops should be thought of as only an aid to cultivation and not as a substitute for cultivation. With the exception of carrots and corn, a great deal more research is required before general suggestions for the use of herbicides in truck crops can be made. In carrots light oils with an aromatic content of approximately 10-16% are suitable for the control of annual weeds and grasses.

2,4-D can be used in sweet corn but definite varietal differences in the tolerance to 2,4-D exist. State recommendations in regard to variety response should be followed. For post-emergence use the maximum safe dosage is $\frac{1}{4}$ pound ester and $\frac{1}{2}$ pound of salts. As pre-emergence treatments the results now available do not warrant general recommendations for the use of 2,4-D in sweet corn.

Pre-emergence treatments in asparagus, beans, beets, onions, spinach and melon crops have shown promise but no specific recommendations can be made. Pentachlorophenols, dinitrophenols, 2,4-D and aromatic oils offer considerable promise, but suitable rates and time of application have not been fully determined.

Post-emergence usage of herbicides can be made in asparagus, onions, and beets but the results that can be expected are dependent on a number of factors and state recommendations are essential. In asparagus cyanamid is safe for the control of young annual weeds. The use of 2,4-D in asparagus is a questionable procedure. Asparagus plants are not usually killed by $\frac{1}{4}$ to one pound acid equivalent per acre, but productivity of the beds may be reduced by repeated treatments.

Onions may be sprayed with sulfuric acid, cyanate or pentachlorophenate but climatic factors affect the results to such an extent that regional suggestions are not warranted.

2,4-D and dinitrophenols are not safe for use in beets.

TCA should not be used in bean or pea crops.

The use of 2,4-D at one pound per acre for the control of annual weeds in strawberries appears to be satisfactory, in a first year planting. In the second season, 2,4-D should not be used during the flowering and fruiting period.

Spot treatment, with suitable chemicals, for the control of perennial weeds in any crop is recommended, even when such treatment will destroy the crop in the treated areas.

F. POTATOES, SUGAR BEETS, LEGUMES AND MISCELLANEOUS CROPS.

Because of inadequate information, 2,4-D, oils, pentachlorophenol, dinitros, and TCA for weed control in potatoes, sugar beets and certain legumes cannot be recommended for field use.

Results with 2,4-D, dinitros and pentachlorophenol on potatoes and on certain established legumes are promising and should receive further study.

Pre-emergence tests with dinitros, pentachlorophenate and pentachlorophenol in oil, and post-emergence treating with sodium and potassium chloride and certain copper salts should be given further attention especially with sugar beets.

Sugar beets, potatoes and some legumes are especially sensitive to TCA. Established legumes, and sugar beets should not be treated with 2,4-D.

Peas have been successfully treated with DNOSBP in many areas. While recommended for peas these materials should be applied according to the manufacturers' directions or recommendations of local weed officials.

G. WOODY PLANTS.

For killing woody plants sensitive to foliage sprays of 2,4-D, concentrations of 2000 p.p.m. (.2 percent) of the ester formulations where drift and volatility is not a problem are recommended. Under humid conditions the same concentration of the salts of 2,4-D may be used. Sensitive woody plants should be sprayed when in an active growing condition.

One pound of 2,4-D acid equivalent in an emulsion of one gallon of diesel oil and four gallons of water per acre applied by airplane as a foliage spray is effective for controlling sand sagebrush on rangeland, when the plants are actively growing.

Concentrated 2,4-D formulations applied to surfaces of stumps and canes cut as closely as possible to ground level will kill some shrubs and trees that are tolerant to foliage sprays of 2,4-D. No minimum concentration has been determined, but not less than 5 percent should be used. This treatment is effective at any season of the year.

Due to the limited time that 2,4,5-T has been under test definite recommendations cannot be made. However, extensive areas have been sprayed with a combination of equal parts of 2,4-D and 2,4,5-T. This combination appears more efficient than using 2,4-D alone. This does not imply that there is definite proof of synergism when these two herbicides are used in combination.

The dry salt of ammonium sulfamate applied to cut surfaces of stumps is recommended for preventing sprouting.

Ammonium sulfamate as a foliage spray is recommended for control of woody plants that are not affected by 2,4-D or 2,4,5-T or when adjacent to sensitive crops.

H. NEW HERBICIDES.

TCA is promising for the control of certain perennial grasses, such as quack, Bermuda, Kentucky blue, and Muhlenbergia species, when used at the rate of 80 to 100 pounds per acre. Johnson grass is more difficult to control. Best results are obtained when optimum moisture conditions for growth of the crop prevail. Inadequate or excessive moisture may affect results adversely. Grasses may be held in check without killing by the use of 10 to 15 pounds per acre. These dosages are based on TCA acid equivalent.

TCA is not selective at these rates and is destructive to valuable grasses, crops and woody plants. Residual toxicity persists for 30 days or more depending upon precipitation. Responses to the sodium and ammonium salts are similar. TCA is compatible with phenolic contact sprays and phenoxy-acetic acid compounds.

Prickly pear cactus has been effectively treated with TCA at one-half pound in one gallon of water applied to wet the plants.

IPC is promising at 3 to 5 pounds per acre for the control of certain annual grasses. The chemical should be present when the seed germinates. It is not recommended for control of perennial grasses and broad-leaved weeds.

PCP formulations show much promise for pre-emergence treatments in large seeded and vegetatively propagated crops. Results with small seeded crops in general have been less favorable.

2,4,5-T is not a substitute for 2,4-D but is effective on certain woody species such as brambles, not easily controlled by 2,4-D. The best method of use is probably in combination with 2,4-D at concentrations of 1,000 to 1,500 ppm of the ester of each as large volumes, foliage wetting applications. Combinations are also recommended for stump treatments.

HAZARDS AND PRECAUTIONS

Spray drift or vapors of 2,4-D and 2,4,5-T may injure or kill susceptible plants in the neighborhood of the application.

Esters are more volatile than the salts and may under certain conditions cause serious injury to susceptible plants at a distance from the point of application.

Coarse sprays are much less likely to drift than fine sprays and equipment and methods should be developed that will favor safe use of 2,4-D herbicides.

REPORT OF COMMITTEE ON NOMENCLATURE

Chemical Names and Designations

The name of the chemical is given in (a) followed in (b) by the forms adopted for common usage. In some instances materials are well known by trade names, but all such designations have been omitted.

1. (a) 2,4-dichlorophenoxyacetic acid
   (b) 2,4-D, acid (indicate carrier or solvent)
   2,4-D, sodium salt
   2,4-D, amine salt (indicate which)
   2,4-D, ester (indicate which)

2. (a) 2,4,5-trichlorophenoxyacetic acid
   (b) 2,4,5-T, acid
   2,4,5-T, salt (indicate which)
   2,4,5-T, ester (indicate which)

3. (a) 2-methyl-4-chlorophenoxyacetic acid
   (b) MCP, acid
   MCP, salt (state which)
   MCP, ester (state which)

4. (a) trichloroacetic acid
   (b) TCA, acid
   TCA, ammonium salt
   TCA, sodium salt

It is further suggested that dosages of this material shall be stated as TCA acid equivalent the same as with 2,4-D.

5. (a) pentachlorophenol
   (b) PCP, phenol (state "in oil" or other carrier)
   PCP, sodium salt

6. (a) 4, 6-dinitro-o-cresol
   (b) DNOC, phenol (state carrier)
   DNOC, ammonium salt
   DNOC, sodium salt

7. (a) 4, 6-dinitro-o-hexylphenol
   (b) DNOCHP, phenol (state form or carrier)
   DNOCHP, salt (state which)

8. (a) 4, 6-dinitro-o-sec-butylphenol
   (b) DNOSBP-phenol (state carrier)
   DNOSBP-amine salt
   DNOSBP-ammonium salt

9. (a) 4-6-dinitro-o-sec-amylphenol
   (b) DNOSAP, phenol (state carrier)
   DNOSAP, salt (state which)

10. (a) isopropyl N-phenylcarbamate
(b) IPC

11. (a) ammonium sulfamate
(b) use full name as in (a)

12. (a) sodium tetraborate
(b) borax

13. (a) sodium chlorate
(b) use full name as in (a)

14. (a) sodium arsenite
(b) use full name as in (a)

15. (a) sodium chloride
(b) salt

16. (a) methyl bromide
(b) use full name as in (a)

17. (a) carbon bisulphide
(b) use full name as in (a)

18. (a) sodium thiocyanate
(b) use full name as in (a)

19. (a) calcium cyanamide
(b) use full name as in (a)

20. (a) sodium cyanamide
(b) use full name as in (a)

21. (a) potassium cyanate
(b) use full name as in (a)

22 (a) allyl chlorophenyl carbonate
(b) use full name as in (a)

23. (a) sodium isopropyl xanthate
(b) use full name as in (a)

24. (a) allyl alcohol
(b) use full name as in (a)

Definitions of Terms

1. Preplanting Treatment. An application made to the soil before the crop seeds or plants are placed in the soil.

2. Pre-emergence Treatment. An application made to the soil after crop is planted but before it has emerged. It may be sub-divided into 1) pre-emergence contact, usually applied just before the crop emerges, to kill weeds that have

emerged and 2) pre-emergence, residual, to kill weeds as they emerge or as the seeds germinate. Some residual sprays may also kill by contact. The term as used here is governed by the crop and not by the weed.

3. Soil Sterilant. A material which renders the soil incapable of supporting plant growth. Sterilization may be temporary or relatively permanent.

4. Contact Herbicide. A chemical or combination of chemicals that kills by contact with plant tissue but is not appreciably translocated.

A committee, consisting of T. F. Yost, Chairman, W. L. Noe, E. O. Witman, H. E. Wood, R. S. Dunham, Loys Smith, and C. J. Willard, was appointed at Topeka to suggest changes in the Constitution of the North Central Weed Control Conference. The draft which they prepared was submitted to the Board of Directors at their meeting Tuesday evening, December 6, 1948, and adopted with certain changes. The Constitution as finally adopted by the Board of Director follows.

CONSTITUTION OF NORTH CENTRAL WEED CONTROL CONFERENCE

Preamble

This conference is established to bring together representatives of the North Central area of the United States, and Canada, and other states and provinces, and agencies, institutions and persons who are directly interested in or engaged in weed control through research, education, regulation, and merchandising. The purpose is to exchange ideas, experiences, opinions and information, and discuss and plan means of securing more adequate weed control through more and better correlated and coordinated effort on weed research and control by Federal, Dominion, State, Provincial, and local public and private agencies.

Article I. Name

The name of this organization shall be the NORTH CENTRAL WEED CONTROL CONFERENCE.

Article II. Membership and Dues

Section 1. Membership shall be of five (5) kinds: (a) state or provincial, (b) active, (c) commercial, (d) associate, and (e) honorary. All memberships shall be for the calendar year for which the dues are paid and shall become effective upon the payment of the dues. Such members shall be considered in good standing until the next year's dues are unpaid.

Section 2. State or provincial membership. The charter state members shall be Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, Oklahoma, North Dakota, South Dakota, and Wisconsin. Other states or other legally established divisions of the U. S. or Canada may be admitted to membership by a two-thirds vote of the board of directors. The annual dues for each shall be $15.00, payable at the beginning of each calendar year. The Conference shall furnish five (5) copies of the annual conference proceedings to the office making the membership payment.

Section 3. Active membership. Active membership shall consist of representatives of the State Departments of Agriculture, State Experiment Stations, State Agricultural Extension Service, United States Department of Agriculture, and such other groups as may be admitted by two-thirds vote of the board of directors. Such representatives shall qualify by spending a substantial portion of their time in weed work. The annual dues for active members shall be determined each year by the board of directors prior to the annual conference meeting. The membership dues shall include registration and a copy of the published proceedings.

Section 4. Commercial membership. Commercial membership shall be open to representatives of commercial concerns interested in weed control products, equipment, or services. Such members shall have the same privileges as active members excepting voting and holding office (or directorships). The annual dues shall be $10.00 per person which shall include registration and a copy of the conference proceedings.

Section 5. Associate membership. Associate membership shall be open to all others actively interested in weed control and eradication. Such members shall have all privileges of active members excepting voting and holding office. Annual dues shall be determined each year by the board of directors prior to the annual conference meeting, which dues shall include registration and a copy of the published proceedings.

Section 6. Honorary membership. Honorary membership may be conferred on persons of distinction who have made outstanding contributions to weed work. Honorary members shall be selected by a two-thirds vote of the board of directors on recommendation of a special committee to consider such nominations. They shall not be liable for dues.

Article III. Governing and Voting

Section 1. Directors to govern. The government of this conference shall be vested in a board of directors, which shall consist of the officers, the director for each state or other legally established division, and five directors-at-large selected from the active membership.

Section 2. Selection of directors. Unless the director has been otherwise selected, the incumbent director shall call a meeting of all active members for his state, province, or other agency not later than the opening day of the annual conference, at which time a director and an alternate director shall be selected for the ensuing year. The method of voting shall be decided by those voting. The directors-at-large shall be selected by the incoming board of directors.

Section 3. Term of office. Directors shall hold office for a term of one year. New directors shall assume office on the last day of the annual conference and shall serve until the last day of the succeeding year's conference, or until their successors have been duly selected. The duties of the alternate director shall be to fill a vacancy as director if and when such vacancy should occur and shall attend board meetings if the regular director is unable to attend.

Section 4. Voting. A majority vote is required in all cases except as otherwise provided. Voting by directorship shall be recorded by the Secretary.

Section 5. Voting between meetings. Voting between meetings of the directors may be conducted by the president or secretary-treasurer by mailing ballots to all directors and notifying them of the purpose of the vote. The call for the vote shall specify a reasonable deadline for the return of the ballots.

Article IV. Officers

Section 1. The officers of the conference shall be a President, a Vice-President, and a Secretary-Treasurer, elected annually by the outgoing board from the active membership. The term of office shall be for one year, or until their successors have been selected and duly qualified.

Section 2. Duly elected officers become members of the board of directors. The president shall act as chairman of the board.

Article V. Meetings

At each annual meeting, the place for the next annual meeting shall be determined by the directors at a time to be decided by the officers and the director for the State or Province where the meeting is to be held.

Article VI. Quorum

Section 1. Two-thirds of the board of directors shall constitute a quorum for transaction of business at any meetings.

Section 2. When voting by mail, ballots shall be sent to all directors. A majority vote of those replying within the specified time limit shall decide the question.

Article VII. Rules of Order

Roberts' Rules of Order shall govern the conduct of all meetings.

Article VIII. Amendments

The constitution or the by-laws may be amended by two-thirds vote of the board of directors at any annual meeting provided previous notice in writing has been given to the directors of the proposed amendments at least thirty days prior to the date of vote.

The following manuscript "Eradication of Herbaceous Plants on Uncultivated Land", Dayton L. Klingman was received too late for sequence inclusion in the printed proceedings.

ERADICATION OF HERBACEOUS PLANTS ON UNCULTIVATED LAND

Dayton L. Klingman[1]

Compared to some other phases in weed control, relatively little work has been done on uncultivated land. The herbaceous vegetation that occupies

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uncultivated land includes all non-woody species (grasses, grasslike plants, and broad-leaf plants). They occur under a wide range of conditions. Each has its specialized problem; however, each may have problems in common with the others or with the plants on adjacent cultivated lands. A topic as broad as that outlined above can only be treated in general terms in the allotted 15 minutes.

I am indebted to the research workers who answered questionnaires for much of the information included in this talk.

Grazing land

Grassland has numerous specialized problems in weed control, varying with its use and the particular area concerned. Considerable research has been done in the control of weeds by range and pasture management. The work of Aldous and others in the control of certain perennials by mowing when the root reserves were low is notable. In pastures generally, the encroachment of weeds has followed reduced vigor of the desirable species. Any weed control efforts that do not recognize the importance of correcting "the cause of weediness" simultaneously with the control measures will be largely wasted effort. In such areas the desirable species must be in good condition to compete either with those that escape treatment or the new seedlings that germinate. Robbins, Crafts, and Raynor have indicated that weed control efforts in grassland should be accompanied by (1) improved management practices, (2) improved soil and fertility conditions, and (3) in some cases the introduction of more vigorous and suitable forage species.

Despite improved management, there still remains the problem of controlling the weeds. The great number of weed species that are detrimental to grasslands, and their diversity of growth habit, tend to make weed control difficult. Thirty different weed species predominant in pasture and range land were listed by the workers answering my questionnaire, and many others could be added. Some are grasses, and others are broad-leaved weeds. No one control procedure or chemical will work for all situations. In addition, the problem areas may be rough and relatively inaccessible for mechanical or other treatment.

In general, the response to my question as to "progress made to date" in grazing land weed control was slight. There has been considerable work with 2,4-D, but mostly only incidental work has been done on the herbaceous grassland species. Most workers emphasized the lack of detailed information in this field. However, Wood reported that with the exception of wild barley 2,4-D (with some qualifications) was effective on the 18 species which he listed. Zahnley and McCall report good control with 2,4-D on Daisy fleabane, mullen, prickly sida, broomweed, brown-eyed Susan, three seeded mercury, and Canada thistle. They also indicate that other predominant pasture weeds can be controlled by repeated treatment at the proper stage with 2,4-D. Bisal reports 70 to 90 per cent control by 2,4-D of hoary cress on plots uncultivated since 1945 (treated in 1946, 1947, and 1948) and a reduction of 90 per cent in stand of Russian knapweed when handled similarly. Erickson reports 50 to 70 per cent reduction of Russian knapweed when treated with 2,4-D plus plowing and reseeding the pasture. Savage et al. report a number of herbaceous pasture weeds that can be killed with 2,4-D and others that are resistant. Other herbicides have been used where 2,4-D is impractical. Mr. F. L. Timmons' informal report of

a trip in the western states has some interesting observations of weed control activities in this regard. Some work being done in California this past year indicates good control of annual grasses by either IPC or TCA at 3 pounds in 120 gallons of water per acre. However, Zahnley and McCall report poor results with ten pounds of IPC on crabgrass. Another effective herbicidal spray reported was that of 3 pounds of IPC plus 3 pints of dinitro in 100 gallons of water per acre. These were believed to be superior to the dinitro sprays used alone. Crafts gives a discussion of the use of dinitros, oils, etc. as control sprays, emphasizing the advantageous creeping qualities of oils where used as a part of the spray material of a contact killer. Minshall and Nelson give a good review of the killing action of oils. By proper timing of application contact sprays might have possibilities for control of some annual weedy grasses in grassland. Zahnley and McCall also report using TCA successfully on crabgrass at 15 pounds per acre, annual brome at 40 pounds, but less favorable results on barnyard grass at 160 pounds, and on fall panicum at 200 pounds.

A little different approach in control when a single species is considered is reported by both Freed and Holloway. They have evaluated two species of Chryselina for biological control of Hypericum perforatum in Oregon and California. We are all aware of the marked success in New South Wales and Queensland in biological control of prickly pear with Cactoblastus cactorum.

Lawns, Parks, Golf Courses, etc.

Other uncultivated grassland areas having a herbaceous weed problem include lawns, parks, and golf courses. While the area is not so extensive as that of grazing lands, there is widespread and perennial interest in this phase of weed control. The use of 2,4-D for control of many of the broad-leaved weeds is now widely accepted. As yet the control of the grassy weeds, notably crabgrass, in these areas is a great problem. Pridham and Nisbet indicate that of the chemicals tested against crabgrass, none have been as successful as 2,4-D when applied at two or three times the dosage needed for dandelion control. 2,4-D is most effective when applied two or three days after germination of the crabgrass seeds. Wolf and Engel report good results with 3 ounces of sodium arsenite in five gallons of water per 1000 square feet. They also indicate promising results with the phenyl-mercury compounds when three or four applications are made to crabgrass seedlings at five-day intervals. DeFrance points out that the phenyl-mercury compounds, in addition to controlling crabgrass, have given good control of certain turf diseases, especially dollar spot. Both sodium arsenite and phenyl-mercury compounds are poisonous and precautions must be taken in their use.

Irrigation and drainage ditches

There is renewed activity in the control of weedy species which are a problem in and along irrigation and drainage ditches. Some of the problems suggested by Hodgson, Freed, Wood, Bakke, Timmons, and others include (1)inaccessibility of some such areas, (2) possible toxicity of chemicals to livestock and humans who might use the water for drinking, (3) possible damage to crops by drift of the chemical or from use of the treated water in irrigation, (4) high cost of treatment, and (5) getting more effective methods of eradication.

In the control of ditchbank and emergent weeds there are some reports of good control with 2,4-D and also with the various fortified oil sprays. The use of seeded grasses and grazing with sheep should not be overlooked as an aid in keeping ditchbanks clean. Pasturing is effective on many species and the cost is low. Little research has been done on this phase, but numerous instances of such practice are cited by the Bureau of Reclamation publication "Control of Weeds on Irrigation Systems". Stahler and Carlson also report reduction of stand of bindweed by grazing when seeded to various legume and grass species. Selective sprays might well fit into such a program to control weed species not palatable to the grazing animals.

There is also a possibility that more effective and cheaper control methods of submerged and floating aquatics will be available in the near future. Moran and Shaw report that certain fractions of coal tar naphtha in the boiling range of xylene and upward are toxic to all species of water weeds. The naphtha to which equal parts of mahogany soap and sulfonated castor oil have been added is emulsified in the canal water by pumping through submerged nozzles at high pressure, five gallons per second foot capacity over a period of one hour.

Farmsteads, fence rows, and rights-of-way

Farmsteads, fence rows, and rights-of-way are often populated by noxious weeds that serve as a source of infestation to nearby agricultural lands. Workers who answered my questionnaire suggest that there is a need for more experiments in chemical and mechanical control of weeds in these situations and also for information as to species of grasses best adapted and methods of their establishment. More work is needed in control of the annual grasses. Pavlychenko and Kirk demonstrated the value of crested wheatgrass for controlling the spread and reducing the stand of nine perennial weed species.

About the only suggestions for controlling weeds in areas where fire may be a hazard are by hand removal or by Borax.

In summarizing, some progress has been made in the control of weeds in uncultivated areas by using 2,4-D and contact sprays. More information is needed as to rates, best dates, and improved means of application in using the chemicals now available. We are also in need of more economic methods of control than those being commonly used if widespread adoption of new methods is to result. This is especially true in areas where the uncultivated land is of low value or adjoins land of low value.

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